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Relative Contributions of Modern Dance, Folk Dance, Basketball, and Swimming to Motor Abilities of College Women[1]

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Abstract

The purpose of this study was to determine the relative contributions of modern dance, folk dance, basketball, and swimming to selected and general motor abilities of college women. Seventy-nine college Freshman women, divided at random into the four classes, were given eleven tests designed to measure agility, co-ordination, general strength, abdominal strength, flexibility, speed, leg strength, power, arm-and-shoulder girdle strength, balance, endurance, and general motor ability. The tests were administered at the end of 16 weeks (one semester) of training. The relative status of the four activities in the development of selected and general motor abilities was first, swimming and modern dance; second, basketball; and third, folk dance.

THE PRESENT STUDY was formulated to determine the relative contributions of four physical education activities to the development of selected and general motor abilities of college women. The specific purpose was to test the hypothesis that there were no real differences in specific and general motor abilities of college women who had participated in different types of physical education activities; namely, modern dance, folk dance, basketball, and swimming. This hypothesis was tested at the end of the treatment period.

Procedure

A survey of the literature revealed that many physical educators have endeavored to test specific and general motor abilities. Basic elements or components of general motor ability have been classified as agility, coordination, strength, flexibility, balance, endurance, etc. (8). A group of the most valid and reliable tests was selected from the literature to measure traits believed to be developed by modern dance, folk dance, basketball, and swimming. Tests selected to measure the various motor abilities were: Burpee—

[1]This report is taken from the findings of a study presented in partial fulfillment of the requirements for the Doctor of Physical Education degree at Indiana University. Only those findings and conclusions pertaining to the relative contributions of modern dance, folk dance, basketball, and swimming to the development of selected and general motor abilities of college women at the end of *one semester* of instruction are presented. The original study (2) also investigated the relative contributions of the four activities at the end of eight weeks of instruction and whether or not a significant improvement in motor abilities occurred during the final eight weeks of instruction.

agility and co-ordination (10, *p. 87*); right grip strength, as measured by the manuometer—general strength (5, *p. 141*); sit-ups for 30 seconds—abdominal strength (10, *p. 89*); trunk flexion forward—hip flexibility (6, *p. 389*); trunk extension backward—back flexibility (6, *p. 389*); ankle flexion—ankle ankle flexibility (6, *p. 389*); obstacle race—speed (9, *p. 193*); standing broad jump—leg strength and power (9, *p. 196*); basketball throw for distance—arm-and-shoulder girdle strength (9, *p. 195*); Bass leap test—balance (1, *p. 35*); Brouha step test—endurance and/or organic fitness (3, *p. 33*); (4, *p. 358*); Scott motor ability battery, composed of standing broad jump, basketball throw for distance, and obstacle race—general motor ability (9, *p. 193*).

The subjects used in this study, who completed the 16 weeks of instruction, were 79 college Freshman women enrolled at Indiana University during the fall semester of 1951-52. They were secured by personal interview and their participation in the study was wholly voluntary. They were given no choice of activity or class period, and all participants had to be deep water swimmers. Grades and credit, as given for regular physical education classes, were awarded. Random tables were used to assign the students to the four groups and the groups to the treatments, which were modern dance, folk dance, basketball, and swimming. Class enrollments were: Modern dance—19; folk dance—21; basketball—20; and swimming—19. The variation in enrollment totals resulted from the loss of three students at the end of the semester because of illness.

All classes were taught by the author. An effort was made to teach them with enthusiasm, making use of good methods and procedures while varying only the content. All of the classes met twice a week for the same length period. Class periods were approximately 50 minutes in length; however, time was allowed for dressing and the actual period of instruction was about 30 minutes. A questionnaire was filled out by the students at the end of the semester concerning participation in outside activities. No significant results were found. The modern dance class was for beginners. The folk dance and basketball classes progressed from beginning to intermediate work and a few advanced skills were taught. The swimming class was at the intermediate level, ranging from low to high.

The 11 tests used in this study were administered to the subjects at the end of the semester. Physical education instructors or graduate assistants administered all the tests. Physical education major students served as recorders or spotters. The author was present at all testing periods.

The analysis of variance statistical technique was employed to test the hypothesis that, at the end of 16 weeks of instruction, there were no real differences in specific and general motor abilities of college women who participated in four different types of physical education activities.

All tests of significance were evaluated at the 5-per-cent level of confidence. In all cases where F was found to be significant, the chi square test for

homogeneity of variance was applied. In no case was a significant chi square found, thus; the presence of homogenity of variance was indicated for all analyses. The within–groups variance was used as the best estimate of the population variance in the standard error of the difference formula when the *t*-test was applied to the group means, taken two at a time. Thus, in evaluating the significance of *t*'s, 75 degrees of freedom were available.

There are two assumptions basic to an analysis of variance: random assignment of subjects and homogeneity of variance. Since both of these assumptions were met, a valid estimate of errors arising from interpupil differences was provided. As many intergroup factors as possible were held constant; however, the interpretation of results is limited to whatever extent intergroup factors might have varied.

When significant *t*'s were found, it was interpreted to mean that the activity group with the larger or better mean score was superior in the trait under test.

All of the original calculations were carried to four decimal places, but are reported to only two places in the following tables. This accounts for what may appear to be slight errors in the *F* and *t* values given in the tables.

Interpretation of Data

Burpee Test. The results of analysis of variance applied to scores received on the Burpee test after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 1.

TABLE 1

Summary of Analysis of Variance Applied to Scores Received on the Burpee Test After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Source of Variation	Sum of Squares	d.f.	Variance	F
Between groups	6.29	3	2.10	
Within groups	38.16	75	.51	4.12
Total	44.45	78		

With 3° and 75° of freedom, an *F* of 2.73 is needed for significance at the 5-per-cent level of confidence. The significant *F* of 4.12 reveals that the four groups are not from the same population as far as agility and co-ordination are concerned.

In order to locate which mean differences were significant, the *t* test was applied to all the combinations of means, taken two at a time. Table 2 contains a summary of these results.

With 75 degrees of freedom, *t* must equal 1.992 for significance at the 5-per-cent level of confidence. Significant *t's* were found between the Burpee test scores of the folk dance group and each of the other three activity groups. Therefore, basketball, swimming, and modern dance are all superior to folk

dance in the development of agility and coordination at the end of 16 weeks of instruction, but there is no difference in the effectiveness of basketball, swimming, and modern dance.

TABLE 2

Summary of the Results of the t Test Applied to Scores Received on the Burpee Test After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Class	N	Mean	Diff.	σ diff.	t	Signif. at 5% level
Basketball	20	6.08				
Folk dance	21	5.37	.71	.22	3.17	Yes
Swimming	19	5.99				
Folk dance	21	5.37	.62	.23	2.73	Yes
Modern dance	19	5.92				
Folk dance	21	5.37	.55	.23	2.44	Yes
Basketball	20	6.08				
Modern dance	19	5.92	.16	.23	.67	No
Basketball	20	6.08				
Swimming	19	5.99	.09	.23	.39	No
Swimming	19	5.99				
Modern dance	19	5.92	.07	.23	.29	No

Right Grip Strength Test. The results of analysis of variance applied to scores received on the right grip strength test after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 3.

TABLE 3

Summary of Analysis of Variance Applied to Scores Received on Right Grip Strength Test After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Source of Variation	Sum of Squares	d.f.	Variance	F
Between groups	2243.90	3	747.97	3.82
Within groups	14675.73	75	195.68	
Total	16919.63	78		

With 3° and 75° of freedom, an F of 2.73 is needed for significance. The obtained F of 3.82 is significant; therefore, the hypothesis that the four groups are from the same population is rejected.

In order to locate which mean differences were significant, the t test was applied to all the combinations of mean scores, taken two at a time. These results appear in Table 4.

With 75 degrees of freedom, t must have a value of 1.992 for significance at the 5-per-cent level of confidence. Significant t's were found between the right grip strength scores of the folk dance group and each of the other three activity groups. In each case, the folk dance group had poorer scores. Thus,

it may be observed that swimming, modern dance, and basketball are better than folk dance for the development of general strength, measured by the right grip strength test, after 16 weeks of instruction. Apparently, there is no difference in the effectiveness of swimming, modern dance, and basketball in the development of this trait after a semester of instruction.

TABLE 4

Summary of the Results of the t Test Applied to Scores Received on the Right Grip Strength Test After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Class	N	Mean	Diff.	σ diff.	t	Signif. at 5% level
Swimming	19	76.84				
Folk dance	21	63.71	13.13	4.43	2.96	Yes
Modern dance	19	75.68				
Folk dance	21	63.71	11.97	4.43	2.70	Yes
Basketball	20	74.40				
Folk dance	21	63.71	10.69	4.37	2.45	Yes
Swimming	19	76.84				
Basketball	20	74.40	2.44	4.48	.55	No
Modern dance	19	75.68				
Basketball	20	74.40	1.28	4.48	.29	No
Swimming	19	76.84				
Modern dance	19	75.68	1.16	4.54	.23	No

Sit-ups for 30 Seconds. The results of analysis of variance applied to scores received on sit-ups for 30 seconds after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 5.

TABLE 5

Summary of Analysis of Variance Applied to Scores Received on Sit-ups for 30 Seconds After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Source of Variation	Sum of Squares	d.f.	Variance	F
Between groups	102.78	3	34.26	
Within groups	491.57	75	6.55	5.23
Total	594.35	78		

With 3° and 75° of freedom, an F of 2.73 is needed for significance at the 5-per-cent level of confidence. The obtained F of 5.23 is significant, which means that the four groups are not from the same population on the trait measured.

In order to locate which mean differences were signficant, the t test was applied to all the combinations of mean scores. These results are presented in Table 6.

With 75 degrees of freedom, t must equal 1.992 for significance at the 5-per-cent level of confidence. Significant t's were found between the abdominal strength scores of the swimming and folk dance; modern dance and folk dance; and the swimming and basketball groups. It may be observed that the folk dance and basketball classes made the poorest scores. Thus, swimming is superior to folk dance and basketball while modern dance is superior to folk dance in the development of abdominal strength, measured by sit-ups for 30 seconds, after a 16-week period of instruction. There are no significant differences between modern dance and basketball; basketball and folk dance; or swimming and modern dance in the development of this trait.

TABLE 6

Summary of the Results of the t Test Applied to Scores Received on Sit-ups for 30 Seconds After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Class	N	Mean	Diff.	σ diff.	t	Signif. at 5% level
Swimming	19	15.63				
Folk dance	21	12.81	2.82	.81	3.48	Yes
Modern dance	19	15.32				
Folk dance	21	12.81	2.51	.81	3.09	Yes
Swimming	19	15.63				
Basketball	20	13.90	1.73	.82	2.11	Yes
Modern dance	19	15.32				
Basketball	20	13.90	1.42	.82	1.73	No
Basketball	20	13.90				
Folk dance	21	12.81	1.09	.80	1.36	No
Swimming	19	15.63				
Modern dance	19	15.32	.31	.83	.38	No

Trunk Flexion Forward. The results of analysis of variance applied to scores received on trunk flexion forward after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 7.

TABLE 7

Summary of Analysis of Variance Applied to Scores Received on Trunk Flexion Forward After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Source of Variation	Sum of Squares	d.f.	Variance	F
Between groups	220.41	3	73.47	7.36
Within groups	748.26	75	9.98	
Total	968.67	78		

With 3° and 75° of freedom, an F of 2.73 is needed for significance at the 5-per-cent level of confidence. The significant F of 7.36 reveals that the four groups are not from the same population as far as trunk flexion forward is concerned.

In order to locate which mean differences were significant, the *t* test was applied to all the combinations of means. Table 8 contains a summary of these results.

TABLE 8

Summary of the Results of the t Test Applied to Scores Received on Trunk Flexion Forward After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Class	N	Mean	Diff.	σ diff.	t	Signif. at 5% level
Modern dance	19	8.36				
Folk dance	21	12.15	3.79	1.00	3.79	Yes
Swimming	19	8.94				
Folk dance	21	12.15	3.21	1.00	3.21	Yes
Basketball	20	9.58				
Folk dance	21	12.15	2.57	.99	2.61	Yes
Modern dance	19	8.36				
Basketball	20	9.58	1.22	1.01	1.21	No
Swimming	19	8.94				
Basketball	20	9.58	.64	1.01	.63	No
Modern dance	19	8.36				
Swimming	19	8.94	.58	1.03	.56	No

With 75 degrees of freedom, *t* must equal 1.992 for significance at the 5 per cent level of confidence. Significant *t's* were found between the trunk flexion forward scores of the folk dance group and each of the other three activity groups. In each case, the folk dance group had poorer scores. Thus, it may be observed that modern dance, swimming, and basketball are superior to folk dance in the development of hip flexibility, measured by trunk flexion forward, after 16 weeks of instruction. Apparently, there is no difference in the effectiveness of modern dance, swimming, and basketball in the development of this trait after a semester of instruction.

Trunk Extension Backward. The results of analysis of variance applied to scores received on trunk extension backward after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 9.

TABLE 9

Summary of Analysis of Variance Applied to Scores Received on Trunk Extension Backward After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Source of Variation	Sum of Squares	d.f.	Variance	F
Between groups	111.81	3	37.27	2.85
Within groups	982.23	75	13.10	
Total	1094.04	78		

With 3° and 75° of freedom, an *F* of 2.73 is required for significance at the 5-per-cent level of confidence. The significant *F* of 2.85 reveals that the four groups are not from the same population on the trait under test.

In order to locate which mean differences were significant, the *t* test was applied to all the combinations of means. A summary of these results is presented in Table 10.

TABLE 10

Summary of the Results of the t Test Applied to Scores Received on Trunk Extension Backward After 16 Weeks of Instruction in Four Different Physical Education Activities by 79 College Women

Class	N	Mean	Diff.	σ diff.	t	Signif. at 5% level
Modern dance	19	16.38				
Folk dance	21	13.10	3.28	1.15	2.87	Yes
Modern dance	19	16.38				
Swimming	19	14.12	2.26	1.17	1.93	No
Modern dance	19	16.38				
Basketball	20	14.60	1.78	1.16	1.54	No
Basketball	20	14.60				
Folk dance	21	13.10	1.50	1.13	1.33	No
Swimming	19	14.12				
Folk dance	21	13.10	1.02	1.15	.90	No
Basketball	20	14.60				
Swimming	19	14.12	.48	1.16	.41	No

With 75 degrees of freedom, *t* must equal 1.992 for significance at the 5-per-cent level of confidence. The only significant *t* was found between the modern and folk dance classes. It appears that modern dance caused the greatest improvement in trunk extension backward over a period of 16 weeks. No other significant differences were located which reveals that basketball, swimming, and folk dance are equally effective in the development of back flexibility, as measured by trunk extension backward after 16 weeks of instruction.

Ankle Flexion, Obstacle Race, Standing Broad Jump, Basketball Throw for Distance, Bass Leap Test, Brouha Step Test, and Scott General Motor Ability Test. The results of analysis of variance applied to scores received on the aforementioned tests after 16 weeks of instruction in modern dance, folk dance, basketball, and swimming by 79 college women are presented in Table 11.

TABLE 11

Results of the F Test Applied to Scores Received on Ankle Flexion, Obstacle Race, Standing Broad Jump, Basketball Throw for Distance, Bass Leap Test, Brouha Step Test, and the Scott General Motor Ability Test

Test	F
Ankle flexion	1.14
Obstacle race	1.83
Standing broad jump	.59
Basketball throw for distance	1.12
Bass leap test	.50
Brouha step test	.43
Scott general motor ability test	1.29

With 3° and 75° of freedom, an F of 2.73 is needed for significance at the 5-per-cent level of confidence. The obtained F's of 1.14, 1.83, .59, 1.12, .50, .43, and 1.29 are too small for significance; therefore, the four groups are considered to be from the same population on the traits measured.

Findings and Conclusions

The statistical analysis of test scores resulted in the following findings and conclusions.

Swimming. The swimming class was found to be significantly superior to the folk dance group in the development of agility and co-ordination, general strength, abdominal strength, and hip flexibility at the end of 16 weeks of instruction. It was also superior to basketball in the development of abdominal strength by the end of one semester. Swimming was equally as effective as modern dance in the development of all the traits tested in this study, and at no time was found to be significantly superior to modern dance.

Modern Dance. The modern dance class was found to be significantly superior to the folk dance group in the development of agility and co-ordination, general strength, abdominal strength, hip flexibility, and back flexibility at the end of 16 weeks of instruction. Modern dance was equally as effective as swimming and basketball in the development of all of the traits measured, and at no time was superior to them at the end of one semester of instruction.

Basketball. The basketball class was found to be significantly superior to the folk dance class in the development of agility and co-ordination, general strength, and hip flexibility at the end of 16 weeks of instruction. The basketball class was equally as effective as the swimming and modern dance classes in the development of all the traits tested in this study, except abdominal strength, at the end of one semester of training. At no time was the basketball class superior to the modern dance or swimming classes.

Folk Dance. The folk dance class was not superior to any of the other three classes in the development of the selected motor abilities measured in this study. However, it was equally as effective in the development of ankle flexibility, speed, leg strength and power, arm-and-shoulder girdle strength, balance, endurance and general motor ability.

In general, it might be concluded that at the end of 16 weeks or 32 periods of instruction, the relative status of the four activities in the development of specific and general motor abilities of college freshman women is first, swimming and modern dance; second, basketball; and third, folk dance.

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(Submitted 2/1/56)

Recent Advances in Measurement and Understanding of Volitional Muscular Strength

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Abstract

In this account, advances in the measurement and understanding of volitional muscular strength of the human organism are presented. Some liberty is exercised in delimiting the report to the following four major aspects of this field: strength measurement, body position and application of strength, certain strength relationships, and strength-decrement fatigue patterns. While brief historical orientation may be made occasionally, the primary emphasis is on recent developments.

HUNSICKER AND Donnelly (31) have described the various devices used to measure human strength during the past 250 years. Certain types of these instruments are in use today, especially back and leg dynamometers and various manuometers. Among the newer forms are the cable tensiometer, Newman myometer, strain gauge devices, and the Kelso Hellebrandt ergograph. Each of these will be described briefly and their use indicated.

Strength Measurement Devices

Cable Tensiometer. The cable tensiometer was orginally designed to measure the tension of aircraft control cable. Cable tension is determined from the force needed to create offset on a riser in a cable stretched between two set points, or sectors. This tension can be converted directly into pounds on a calibration chart.

Starting as a problem to measure the strength of muscles affected by orthopedic disabilities, Clarke (4, 8, 10, 15) adapted this instrument for strength testing. Thirty-eight strength tests were subsequently devised to measure the strength of muscles activating the following joints: fingers, thumb, wrist, forearm, elbow, shoulder, neck, trunk, hip, knee, and ankle. Research in the construction of these tests included: determination of body position which permitted greatest application of strength for each joint movement; selection of the joint angle which resulted in the strongest movement; and the study of such factors as the position of the pulling strap and the effect of gravity on test scores. Consultation on the kinesiological determination of potentially desirable positions for each test was had with physiatrists at the Mayo Clinic. For the most part, the objectivity co-efficients for the various tests were in the 0.90's. A manual describing these tests is available (5).

An illustration of the cable tension test for elbow flexion appears in Figure I. The subject is in a supine lying position, hips and knees flexed, feet resting on table; the arm on side tested is adducted and extended at the shoulder to 180 degrees, the elbow is in 115 degrees flexion; the center of the pulling strap is midway between the wrist and elbow joints; and the cable is so attached that the pull is at right angles to the forearm.

FIGURE I. Elbow Flexion Strength Test with Tensiometer.

Newman Myometer. The Newman myometer consists of a cylindrical housing enclosing the complete mechanism. Extending from one end is a shaft with a pressure transmitting button; a dial gauge is located at the other end. A built-in hydraulic pressure converter transmits the force exerted on the button to the pressure gauge. The tester pushes the transmitting button against the body part acting as lever; the strength score is recorded at the point where the subject "breaks," i.e., is unable to resist the pressure applied and gives way. Maximum capacity of this instrument is 60 pounds.

Strain Gauge Devices. The most recent advance in the field of strength testing is based upon the principle underlying the electrical strain gauge. As reported by Hunsicker and Donnelly, the theory of a wire changing its electrical resistance when stretched was advanced 100 years ago by Thomson (41). Ralston and associates (39) devised such a device in 1947 to study the strength of isolated muscles of upper-arm amputees with cineplastic muscle tunnels. Strain gauges were affixed to two aluminum rings and connected in a conventional Wheatstone bridge arrangement. A galvonometer was used to detect bridge imbalances; and an oscillograph was the recording instrument. Carlson and Martin (1) developed an apparatus for eliciting a stretch reflex and record-

ing electrically the isometric responses of the muscle by means of strain gauges.

Wakim and associates (44) have described a strain gauge device for cable-tension strength testing. Two strain gauges are attached to the outside and two to the inside of an aluminum alloy ring approximately 4 cm. in diameter and 2.6 mm. in thickness. These elements are connected by separate wires to complete a circuit containing a galvonometer, a battery, and a 20-watt bulb. Changes of resistance on the strain gauge cause deflections in the galvonometer. Two "slivers" of light are produced by reflection from the galvonometer: one of these lights remains fixed at a zero point; and the other is deflected with the amount of resistance applied to the ring in strength testing. The slivers of light from the galvonometer are reflected on a slit in a device containing slowly revolving photostat paper, although it may also be used by reflecting the lights on a transparent plastic scale.

Tuttle and associates devised dynamometers based on the strain gauge principle for measuring the maximum strength and strength endurance of grip strength (43) and back and leg muscles (42). The sensitive element is a Baldwin SR-4 Type U-1 load cell with a rated capacity of 500 pounds. This cell contains a central member which is strained when a load is applied to the cell; the amount of this strain is measured by resistance wire strain gauges which are connected in a Wheatstone bridge. Forces are applied to the load cell by means of a steel bar. By moving the fulcrum on the bar, pulls up to 3000 pounds are possible in a capacity pull of 500 pounds on the load cell. Recordings are made by use of the Easterline-Angus recorder. Maximum strength is defined as the highest point on the strength curve; the strength endurance index, as the average strength maintained at maximum force for one minute for grip and leg tests and 30 seconds for back lift.

The Anthropology Section of the Aero-Medical Laboratory of Wright-Patterson Air Force Base has designed a Kinematic Muscle Study Machine, which employs strain gauges and which can test forces in three directions simultaneously (30). The handle of this instrument is constructed around a swivel-joint; the placement of 16 strain gauges is so arranged as to pick up distortion in the various planes.

Kelso-Hellebrandt Ergograph. F. A. Hellebrandt and associates have provided a comprehensive review of the origin and development of ergography (26). The early ergographs, such as the one used by Mosso to study the fatigue of human muscles, confined the research to finger movements. Since then, many changes in this instrument were proposed. None of these, however, could accurately compute the total work done by contracting muscles, as the angle of pull changed throughout the range of motion of the joint.

More recently Kelso, in co-operation with Hellebrandt, devised a wheel and axle in place of the Mosso sling, so arranged that the angle of pull remained the same during the entire movement. Located on the ergograph are two counters: one of these records the number of movements made by the sub-

ject; the other is a distance meter which records cumulatively the total distance the subject raises the load. Also provided are a kymography, a mechanical chronograph driven by a 6 R. P. M. synchronous motor, and a voltage reduction and insulating transformer. Six such ergographs have been devised for movements of the following: thumb, wrist, grip, radioulnar, elbow, and shoulder (24, 25, 26).

In testing with the ergograph, Hellebrandt adopted a "limit day" procedure, which consisted of repetitive bouts of a set number of contractions each against progressively increasing resistance: with the resistance increment the same each time and 30-second pauses between bouts. This technique was employed extensively in studies pertaining to disability evaluation.

Clarke (11, 13) studied the use of the Kelso-Hellebrandt ergograph in single-exercise bouts of the elbow flexor and shoulder flexor muscles. The position of the subject for the shoulder flexion movement is shown in Figure II. The essential feature in achieving precision is in determining the proper load to place on the ergograph carriage, which may be determined as a proportion of the strength of the muscles exercised. For an eight-inch ergograph lever arm and at a cadence of 30 repetitions per minute, the proportions are: three-eighths of elbow flexion strength for elbow flexion ergography; and five-eighths of shoulder flexion strength for shoulder flexion ergography. The greater proportion required for the shoulder flexion movement is attributed to the fact that the muscles are able to exert greatest strength at the start of the movement, when the arm is alongside the body; for elbow flexion, the strong position is between 100 and 140 degrees, with a 28 per cent decrease in strength at the extended position.

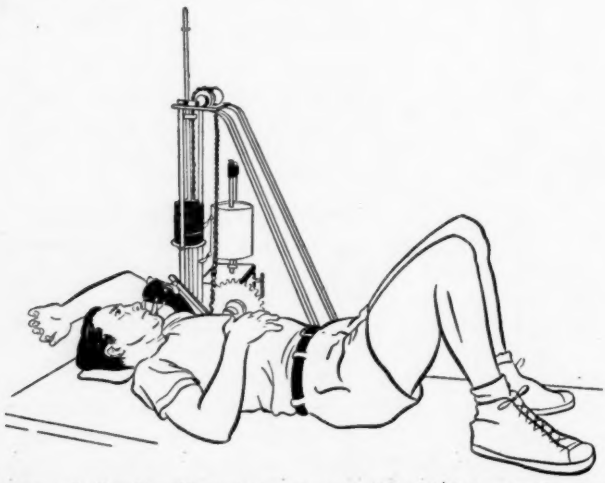

FIGURE II. Shoulder Flexion Exercise with Kelso-Hellebrandt Ergograph.

Body Position and Strength Application

A number of studies have been conducted to determine the amount of strength which can be applied by the same muscles when the body parts are in different positions. An early study was performed by Carpenter (2) in determining the best angle for the knees in performing the leg-lift test with the back and leg dynamometer. The angles ranged from 75 to 169 degrees. The maximum leg lift was obtained when the knee angle was beween 115 and 124 degrees. In this research, the leg lift was given without the use of a belt around the waist to hold the lifting bar firmly in position.

Extensive experiments of this sort were carried out by Clarke and associates (16) in the construction of his cable-tension strength tests. For example: 1. A 90-per-cent mean increase in hip flexion strength was found when the subjects were in supine lying with leg extended as contrasted with sitting at end of table leaning backward, arms extended to the rear and hands grasping table; 2. A mean increase of 24 per cent in knee extension strength was obtained when the subjects were sitting at end of table leaning backward and grasping sides of table as contrasted with the same position but sitting upright with arms folded; 3. A 109-per-cent increase in mean ankle plantar flexion strength was achieved when the subjects were in supine lying with straight hip and knee and ankle in 90 degrees dorsal flexion as contrasted with sitting at end of table, legs hanging free.

Other studies have investigated the amount of muscular strength applied throughout the range of motion of various joints of the body. Clarke and Bailey (14) reported three general types of strength curves as follows: 1. Ascending, as in shoulder flexion (Figure III) : the weak position is with the arm over the head and the strong position is with the arm alongside the body; 2. Desending curve, as in elbow extension (Figure IV) : the strong position is with the elbow bent to 40°, dropping gradually to a low point at full extension; 3. Ascending-descending curve, as in elbow flexion (Figure V) : here the strong position is in the center of the range of motion. Elkins, Leden, and Wakim at the Mayo Clinic (23) corroborated the strength curves reported above for the elbow extensors and flexors. Provins at the University of Oxford (35, 36, 37) studied the maximum forces about the elbow and shoulder joints. The mid-position was again the favored position for the elbow joint in flexion; elbow extension strength was approximately 73 per cent of flexion and shoulder extension was 119 per cent of flexion; and significant differences in torque were found between positions employing attempted movement about the elbow and shoulder joints in favor of the shoulder joint.

Hunsicker (30) investigated the amount of force a human subject could exert with the arms when the elbows were at 180, 150, 120, 90, and 60 degrees. Six movements were made at each angle: pull, push, lift up, push up, abduction and adduction, in both sitting and prone positions. Among his findings were: the amount of flexion in the elbow reduced a strength score to 44 per cent of its maximum value, although the mean reduction was 28 per cent;

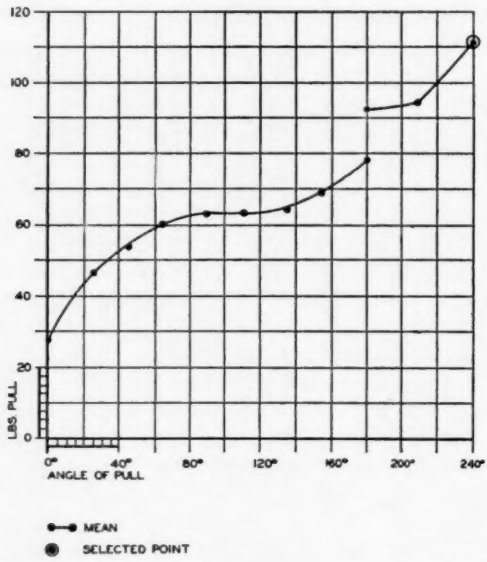

FIGURE III. Ascending Strength Curve: Shoulder Flexion.

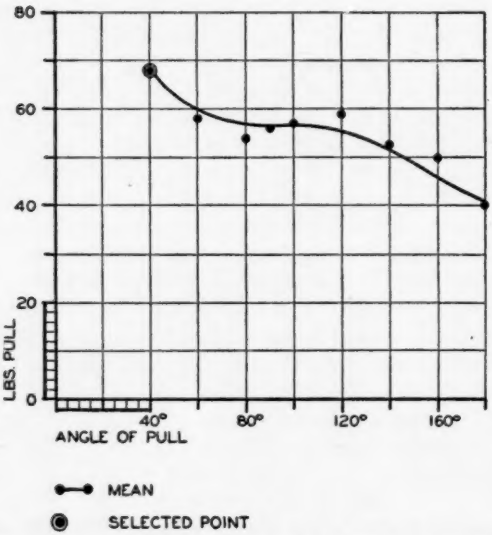

FIGURE IV. Descending Strength Curve: Elbow Extension.

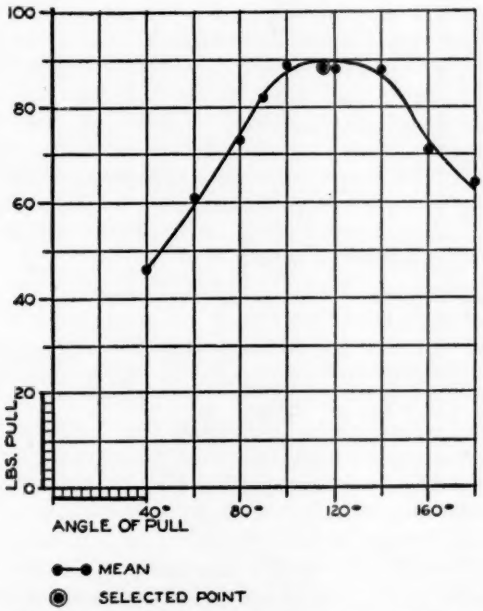

FIGURE V. Ascending-Descending Strength Curve: Elbow Flexion.

in the sitting position, the order in which greatest force could be applied was push, pull, up, down, adduction, and abduction; the order in the prone position was pull, push, up, adduction, down, and abduction; in both the sitting and prone positions, the weakest action was approximately one-third of the strongest; and, generally speaking, the prone position was 71 per cent as strong as the sitting position.

In a study of the effect of limb position in seated subjects on their ability to utilize the maximum contractile force of the limb muscles, Hugh-Jones (29) found that, in general, push and pull amounts increase with extension of the acting joint until a maximum is reached just before the joint becomes straight. This factor has long been recognized by physical educators in back and leg lift testing with conventional spring-type dynamometers (6).

Ralston and associates (38, 39) studied the pectoralis major, biceps brachii, and triceps muscles under isometric and isotonic conditions in amputee subjects having cineplastic muscle tunnels. Among their findings are: 1. The isometric length-tension diagram and the load-work curve were similar to those previously described for frog muscle; 2. The curve of developed tension has a maximum in the neighborhood of the resting length of the muscle, which again, is in agreement with earlier studies on frog muscle; 3. The curve of passive stretch represents an exponential function; 4. Under conditions of

relatively slow and uniform speed of contraction, the excursion of the freely weighted muscle is shown to be a linear function of load, and proof is offered that a parabolic relation between load and work necessarily follows from the relationship; 5. The curve relating load and maximum velocity could be fitted by Hill's equation, $(P+b)\ (V+b) = \text{constants}$, for frog muscle; the constants of the equation, however, are different from those obtained in frog muscle. Wilkie (45) has verified this latter relationship, although he points out two difficulties in interpreting such results with human muscle: that the muscles are not arranged geometrically in any simple way; and the degree of activition may vary during the movement.

Certain Strength Relationships

Considerable research has been done in the relationship of strength to health, physical condition and efficiency, and athletic performance. Recent studies on the relation of maximum strength to strength endurance of the grip (43) and back and leg (42) muscles have been conducted by Tuttle and associates. Their strain gauge instruments and methods of determining strength and the endurance index have been described above. Their findings for college men are: 1. Individuals with the greater maximum strength have a greater absolute strength endurance index (correlations for back and legs around 0.90); 2. Stronger individuals can maintain a smaller proportion of their maximum back and leg strength than those with weaker initial strength (correlations from –0.40 to –0.48 with endurance based on one minute); 3. The development of strength endurance was not directly proportional to the development of strength.

Clarke (9) reported the following observations from single-bout ergographic studies:

1. The amount of weight required to induce exhaustion in a relatively short time varies among individuals, depending on the strength of the involved muscles: the amount of weight for each subject may be determined as a proportion of that strength. This observation was verified by Clarke and Herman (3) at Brooke Army Hospital when they obtained nearly a straight line decrease in the mean number of repetitions in exercising the knee extensors when the weights used varied from 30 to 50 per cent of knee extension strength.

2. The work output of muscles in exhaustion performances is greater when in a position to apply greatest strength at the point of greatest stress (See Figures III and V).

3. In this and another study (17), under conditions of ergographic exercise to exhaustion, approximately two minutes of exercise each session, gains in muscular strength and endurance were 11 and 13 per cent respectively during a four-week period; no appreciable deconditioning took place in either element during a four-week lay-off from ergographic exercise.

Hellebrandt and associates made a number of conditioning studies with the ergograph. Among their findings were: 1. The uninterrupted maintenance of

a sustained contraction against heavy resistance produced a fatigue curve which was strikingly similar in its characteristics to the ergogram yielded by repetitive effort (27); 2. Training curves are erratic, being affected by many factors, including motivation ("power of the psyche") and various health habits (27); Exercise of one limb not only augments the strength of the ipsilateral exercised limb, but has a pronounced concomitant effect on the contralateral limb (28). In a later study, Slater-Hammel (40) verified this phenomenon, while Clarke, et al., (17) reported a cross transference of muscular strength but not muscular endurance from ergographic exercise.

Clarke (12) determined the relationship between strength and various anthropometric measures of the arms and shoulders. Correlations of 0.73 were obtained between girth of the flexed-tensed upper arm and the McCloy arm strength score; multiple correlations reached 0.81 when standing height and shoulder inward rotation and shoulder flexion strengths were added. The subjects in this study, however, were highly selective, being dominantly mesomorphic with some tendency toward meso-ectomorphy.

Strength Decrement and Fatigue Patterns

Strength decrement of the elbow flexor muscles following exhaustive exercise was studied by Clarke, Shay, and Mathews (20). The elbow flexor muscles were fatigued through single-bout exercise sessions on the Kelso-Hellebrandt ergograph, the weight load being three-eights of each subject's elbow flexion strength. Cable-tension elbow flexion strength tests were given to each subject 30 seconds after exercise and at five- to ten-minute intervals for some time to note the strength recovery rate. Under these conditions, the initial drop in strength 30 seconds after exercise was pronounced (29 to 32 per cent); the initial gains were rapid, followed in about 10 minutes, by a very gradual recovery rate. Strength recovery was not complete 45 minutes to two hours after exercise. Some evidence exists that the recovery at the end of 45 minutes is greater when the subjects move about between post-exercise strength tests, thus increasing general body circulation, than when they lie quietly during this period. A Strength Decrement Index (SDI) was proposed as the per cent loss in strength (21).

These investigators utilized the SDI to determine the muscular fatigue pattern in marching and carrying military packs under field conditions (18). Each march was 7.5 miles; the rate of march was 2.5 miles in 50 minutes; packs and loads varied. Eleven muscle groups were tested immediately before each march and at the end of each 2.5 miles during the march. Fatigue patterns varied for the different packs studied. For example, the knee flexors and knee extensors showed greatest loss when the 41-pound combat pack was carried high on the back; and the shoulder elevators and knee flexors were affected most when this pack was carried low on the back. A similar study (19) was made of the strength loss effects on the muscles of the lower leg and ankle resulting from wearing three types of army boots and shoes on 7.5 mile marches carrying combat packs. Again, fatigue patterns were revealed;

marches with the combat boot showing least fatigue. In still another study, Davis (22) reported SDI's from swimming the 200-yd. crawl stroke for time. The greatest mean SDI was 22 for the shoulder extensor muscles, the arm-pulling muscles in swimming this stroke.

Mathews, Shay, and Clarke (33) determined the relationship between strength loss from carrying military packs under field conditions and various motor-physical fitness tests. The subjects were conditioned from six marches carrying the combat load of the rifleman. On the final march, they carried 61 pounds with rucksack for 7.5 miles at a rate of 2.5 miles in 50 minutes. The highest multiple correlation obtained was -0.92 between strength loss and the Strength Index; similar correlations with the Army, Navy, and AAF motor fitness tests were between -0.57 and -0.49. Individual test items of special significance in this study were leg-lift strength, time in the 300-yd. run, and number of squat thrusts in one minute.

Summary and Conclusions

In this report, certain recent advances in the measurement and understanding of volitional muscular strength of the human organism were presented. A brief summary of this research and the conclusions which appear tenable follow.

1. Among the newer forms of strength testing instruments are the cable tensiometer, strain gauge devices, and the Kelso-Hellebrandt ergograph. Clarke (7) compared the effectiveness of four such instruments for recording muscle strength: cable tensiometer, Wakim-Porter strain gauge, spring scale, and Newman myometer. As reflected by objectivity coefficients, the cable tensiometer had greatest precision for strength testing. It was the most stable and generally useful of the instruments; and was free of most of the faults of the other devices. The strain gauge had a satisfactory degree of precision, but was more sensitive to slight tensions, including changes in room temperature. Pronounced stretching of the testing unit of the spring scale permitted joint movement beyond the degrees specified for each test; such movement also allowed change in the 90-degree angle of pull required of all tests. These factors reduced test scores as compared with the other instruments. Considerable difficulty was experienced in testing with the myometer, the objectivity coefficients being relatively low; and test scores were much lower than those obtained with the tensiometer.

2. The Tuttle strain gauge dynamometers had satisfactory objectivity coefficients; and had the additional advantage of measuring isometric muscular endurance. The back and leg dynamometer permitted testing to 3,000 pounds. Kennedy (32) also adapted a tensiometer for back and leg strength testing, permitting a maximum 2400-pound lift; however, his adaptation does not provide for measurement of muscular endurance.

3. The Kelso-Hellebrandt instruments mark an important advance in the measurement of isotonic muscular endurance. Techniques for both "limit day" and single-bout ergographic testing have been developed.

4. Studies conducted to determine the amount of strength which can be applied by the same muscles when the body parts are in different positions have provided evidence for the following assumptions: that, other things being equal, a muscle exerts its greatest power when it functions at its greatest tension; that the angle at which a muscle pulls is important but probably not as significant as the tension; that the mechanical arrangements of the levers sometimes interfere with full application of strength, even though the muscles may be at their greatest length; and that there probably is an optimum position at which each muscle group functions best.

5. Studies on the volitional action of human muscles have revealed that some actions at least are similar to those previously described for frog muscle, including: the isometric length-tension diagram, the load-work curve, the curve of developed tension, and Hill's equation relating load and maximum velocity (although the constants of the equation are different).

6. Tuttle obtained a correlation of 0.90 between maximum strength and his strength endurance index (based on constant isotonic contraction); and a negative correlation (-0.40 to -0.48) between maximum strength and isotonic maintenance of the proportionate amount of this strength. Other significant findings relative to the muscular strength-endurance relationship are: The amount of weight required to induce exhaustion in a short time depends on the strength of the involved muscles (at least with unconditioned subjects); the work output of muscles in exhaustion performances is greater when in a position to apply greatest strength at the point of greatest stress; training curves are erratic, being affected by such factors as motivation and various health habits and exercise of one limb produces cross transference of conditioning elements to the contralateral limb.

7. Measurable strength loss results from exhaustive exercise. Under one set of laboratory conditions, the amount of this loss was approximately one-third of pre-exercise strength. Strength recovery during the first ten minutes was rapid, followed by a very gradual increase; strength recovery was not complete 45 minutes to two hours after exercise.

8. By determining the strength loss of various muscle groups involved in a fatiguing activity, muscular fatigue patterns may be obtained. This technique has been successfully used in pack-carrying and swimming studies.

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Physiological Maturity of Little League Baseball Players

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Abstract

The physiological maturity of the 112 boys who participated in the 1955 Little League World Series was determined by means of the Crampton pubic hair index. The majority of these boys, who were chronologically 10, 11, and 12 years of age, were adolescent. Only 17 per cent of the boys were pubescent, whereas 37.5 per cent were prepubescent and 45.5 per cent were postpubescent. This suggests that the ability to play baseball is affected by the puberal spurt in growth. The postpubescent boys were equal in height and weight to the average 14-year-old boy. More pitchers and first basemen were postpubescent than players at other positions. Position in the batting order definitely reflected maturity.

STUDIES HAVE SHOWN that the rate of maturation has a significant effect upon physical growth, behavior, mental development, emotional tension, social adjustment, personality and motor learning. The purpose of this study was to determine the physiological age of the Little League baseball players who participated in the 1955 World Series.

Review of the Related Literature

Numerous studies have shown that early maturing children are taller and heavier than late maturing children (1, 2, 4, 5, 7, 9, 18, 21, 28, 29, 30, 33). Crampton (9) reported mature boys are 33 per cent heavier, 10 per cent taller, and 33 per cent stronger than immature boys of the same chronological age. According to Dimock (9), 13-year-old prepubescent boys were found to average four inches shorter and 20 pounds lighter than postpubescent boys of the same age. Jones (17) found that the early maturing boys are larger in physical size than late maturing boys at all ages from 11.7 to 17.7 years. In the Harvard Growth Study (29), it was shown that the difference in size was noticeable as early as six years of age and this difference remained evident until 18 years. Jones and Bayley (21) demonstrated that as early as 11 years of age the late maturing boys were not so tall as the early maturing boys. The late maturing boys were small, slender, and long-legged.

That early maturation favors good scholarship and late maturation poor scholarship has been reported in several studies (3, 6, 14, 15, 26, 30). Cramp-

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ton (6) stated on the basis of his findings, "the higher grade scholars of equal ages are demonstrably older in pubescence to the value given in years."

In a comparison of ten boys who scored high in strength tests with ten boys who scored low in strength tests, it was found that the ten high boys indicated a tendency toward a good physique, physical fitness, early maturing, social prestige, and satisfactory level of personal adjustment. The ten low boys were late maturing, with asthenic physique, poor health, social difficulties, and lack of status. They also exhibited a feeling of inferiority and poor personal adjustment in other areas. Six of the low group were late in physiological maturing (17). Porter (27) stated, "the psychological difference between the individual children in an anthropometric series and the physical type of the series is directly related to the quickness of growth."

Physical maturity has also been shown to have a definite effect upon behavior. The late maturing boys have been found to be talkative, peppy, uninhibited, attention-seeking, and to exhibit a tense behavior pattern, whereas the early maturing boys have been found to be much different than late-maturing boys in that they were more calm, exhibited a relaxed behavior pattern, and possessed a physical attractiveness, "matter-of-factness," and "unaffectedness." In high school, the early maturing boys became student leaders. Of the 16 early maturing boys studied, two of the 16 became student body presidents, one was president of the boys' club, several were committee chairmen, and four were outstanding athletes. In the group of 16 late maturing boys, one became vice-president and one was an athlete. The authors (21) concluded that, "findings give clear evidence of the effect of physical maturity on behavior."

Todd (32) suggested that the difference in development may be a contributing factor in the difference in school adjustment of boys and girls. Prestige differences between early maturing boys and late maturing boys were apparent in mixed groups. The early maturing boys were most likely to get and maintain prestige associated with athletics and office-holding, while late maturing boys compensated to some extent by greater activity and striving for attention (21).

In his book, *Tests and Measurements in Health and Physical Education*, McCloy (25) pointed out the influence of physiological age on performance and gave some supporting evidence. One of the best studies of motor performance and stages of growth was that of Espenschade (10). She noted: "It has long been recognized that older, taller, and heavier children are stronger and in general more proficient in activities than are younger, shorter, and lighter children." These were also the findings of other researchers (22, 23, 24).

Jones and Bayley (21) demonstrated that in the Espenschade test of motor ability the late maturing boys were below average and the early boys were greatly superior in both strength and skill. A comparison of 1,028 Cleveland High School athletes and non-athletes revealed the athletes to be two years

advanced biologically (20). Colored boys have been found to mature more rapidly than white boys (16).

During pubescence, Dimock (8) reported a slowing down in rate of increase in motor ability and related this to the concept of adolescent awkwardness. Jones (17) wrote of a recession in performance in the early part of postpuberty at a skeletal age of 14 years. Espenschade (11) found a lag in the development of motor ability between the chronological ages of 12.5 and 14 years. In another study, Espenschade substantiated the hypothesis that growth in dynamic balance is retarded at puberty (12).

In using the Crampton criteria as a measure of physiological maturity, it is important to note that some pubic hair ratings might have been obtained earlier or later and that there is a wide variation in the length of time it takes a boy to develop from one pubic hair rating to the next (31). Although Crampton (7) urged caution in giving any one year as the age of prepubescence, pubescence or postpubescence, Dimock (9) reported the average age of postpubescence in boys as determined by the character of pubic hair to be 14.6 years. Using the same criteria, Carey (4) found the average age of pubescence to be slightly more than 14 years.

About Little League

Little League Baseball is a program for boys 8-12 years of age, but for tournament play in 1955 only boys 10, 11, 12 years of age were eligible. The organizational unit of the Little League program is a four-team league, each team consisting of not more than 15 players. The tournament team of 14 players is selected from the four teams in the league. Since there were approximately 4,000 leagues participating in Little League in 1955, there was a potential of approximately 4,000 tournament teams. Playing in the tournaments, however, is not mandatory but is the prerogative of each league.

Procedure

SUBJECTS

The subjects for this study were the 112 boys who participated in the 1955 World Series played in Williamsport, Pennsylvania. One boy was 10 years of age, 19 were 11 years of age, and the remaining 92 were 12 years of age. The average age was 12.53 years. The various states represented in this national tournament included Alabama, California, Louisiana, Massachusetts, Michigan, New Jersey, New York, and Pennsylvania. Six of the subjects were Negro and the remainder white.

PHYSIOLOGICAL AGE

Physiological age was determined by the criteria suggested by Crampton (7). Boys were considered prepubescent if they had no pubic hair other than fine hair like that present on all parts of the skin. They were considered pubescent when there was pigmentation in the pubic hair, and they were considered post-pubescent when the pubic hair was kinked or twisted.

HEIGHT AND WEIGHT

The height and weight of each subject was also taken. Height was recorded to the nearest quarter of an inch and weight to the nearest quarter of a pound. All measurements were taken with the subjects in the nude.

Findings

PUBESCENT STATUS

The pubescent status of the subjects is presented in Table 1. Almost 50 percent of these 10-, 11-, and 12-year-old boys were postpubescent and the next largest group was the prepubescent. Since puberty is considered the moment of beginning adolescence, 62.5 per cent of the subjects were adolescent and 37.5 per cent were preadolescent. It is important to note that only 17 per cent of the subjects were found to be pubescent—i.e., in the period of rapid growth.

TABLE 1

Pubescent Status of Players in the 1955 Little League World Series

PREPUBESCENCE		PUBESCENCE		POSTPUBESCENCE	
Number of Subjects	Per Cent	Number of Subjects	Per Cent	Number of Subjects	Per Cent
42	37.5	19	17	51	45.5

Age, Height, and Weight. (See Table 2.) The average chronological age for the young ball-players was 12.53 years. Forty-seven of the 12-year-olds were found to be post-pubescent; 16 were pubescent; and 29 were prepubescent. Of the 11-year-olds, four were postpubescent, three were pubescent, and 12 were prepubescent. The only 10-year-old was prepubescent. In relation to their pubescent status, the postpubescents were ten months older than the prepubescents and four months older than the pubescents. The pubescent boys were on the average six months older than the prepubescent boys.

TABLE 2

Pubescent Status of Players in the 1955 Little League World Series in Relation to the Mean Age, Height, and Weight

Criterion	Prepubescence	Pubescence	Postpubescence	Total Group
Age (years)	12.11	12.60	12.97	12.53
Height (inches)	59.02	60.30	63.20	61.00
Weight (pounds)	95.36	96.05	116.54	104.80

The range in height for the entire group of subjects was 51½-69¼ inches, the average being 61 inches. The prepubescent group ranged in height from 51½-64½ inches; the pubescent group, 56½-65¼ inches, and the postpubescent group 51½-69¼ inches, respectively. Although there was slightly more than a one-inch difference between the prepubescent and the pubescent sub-

jects, there was more than a four-inch difference between the postpubescent and prepubescent boys.

The greatest difference between subjects of different pubescent status was in weight. There was less than a one-pound difference between the prepubescent and the pubescent subjects, but the postpubescent group exceeded the prepubescents and the pubescents by more than 20 pounds. The range in weight for all subjects was from 64-178 pounds, the average being 104.8 pounds. The range for the prepubescent group was 64-138 pounds; for the pubescent group 72-127 pounds, and for the postpubescent group 78-178 pounds. The average weights were 95.36, 96.05, and 116.54 pounds respectively.

Race. Five of the six Negroes were found to be postpubescent and the other was prepubescent.

Position in Baseball. In baseball, the most important defensive player is the pitcher and in Little League a boy who can throw the ball hard is generally selected to pitch. In comparing the positions with the pubescent status (Table 3), it is obvious that the pitchers are among the most mature subjects. Seven of the eight pitchers that started games in the World Series were postpubescent and the other pitcher was pubescent. The only other two positions in which this pattern was noticeable was at first base and left field where, of the starting line-ups, six of the first basemen and six of the left fielders were postpubescent. Only one of the first basemen and two of the left fielders were prepubescent.

TABLE 3

Pubescent Status of Players in the 1955 Little League World Series in Relation to Their Defensive Position

Defensive Position	Pubescent Status		
	Prepubescence	Pubescence	Postpubescence
Pitcher	0	1	7
Catcher	4	1	3
First Base	1	1	6
Second Base	4	2	2
Third Base	4	3	1
Shortstop	6	0	2
Left Field	2	0	6
Center Field	2	1	5
Right Field	3	1	4

Batting Order. Although managers in Little League do not select their batting orders according to the pubescent status of the ball players, Table 4 reveals that the most mature boys are placed in the batting order where "batting power" is most desired.

In baseball, the most powerful hitter is placed in the "clean-up" position or fourth in the batting order. In the Little League World Series all eight of the boys listed in the starting line-up to bat in the "clean-up" position were postpubescent. The other strong positions in the batting order (3rd, 5th, and

TABLE 4

Pubescent Status of Players in the 1955 Little League World Series in Relation to Their Batting Order

Batting Order	Pubescent Status		
	Prepubescence	Pubescence	Postpubescence
First	5	1	2
Second	4	2	2
Third	1	1	6
Fourth	0	0	8
Fifth	2	1	5
Sixth	2	0	6
Seventh	2	2	3
Eighth	7	1	0
Ninth	3	1	4

6th) also show the most mature boys batting in these positions. Six of the eight subjects in the 3rd position were postpubescent, five of the eight batting in the 5th position were postpubescent and six of the eight batting in the 6th position were postpubescent.

Discussion

It is obvious that the boys who participated in the 1955 Little League World Series were much more mature than would be indicated by their chronological age. Although these boys were only 10, 11, and 12 years of age, approximately 50 per cent of the boys were postpubescent, which would indicate, according to previous findings, that these boys were as mature as the average 14- or 15-year-old. Only 37.5 per cent of the boys were prepubescent and these boys could not be categorized as retarded, normal, or precocious in their maturation because there is no indication of how long they will remain prepubescent. Since these boys were only 10, 11, and 12 years of age, it is possible that many of the prepubescent boys could soon become pubescent and would, therefore, also be classified as maturing early.

The height and weight of the postpubescent boys is equal to the height and weight of the average 14-year-old boy, according to the latest statistics from the U. S. Office of Education (34, 35). The average height and weight of 14-year-old boys, measured while subjects were wearing shoes and indoor clothing, was 64.5 inches and 117.4 pounds. The postpubescent subjects in this study, measured in the nude, were 63.2 inches in height and 116.5 pounds in weight. If both groups of subjects had been measured while in the nude, the weight and height of both groups would have been almost identical.

It is important to note that only 17 per cent of the boys participating in the national tournament were pubescent, whereas 37.5 per cent were prepubescent and 45.5 per cent were postpubescent. The reason for the small number of pubescent boys has been explained by the findings that pubescence is the period of rapid growth during which there is a necessary adjustment in motor performance. Although strength may not be disrupted by the rapid growth at

the onset of adolescence, agility, balance, and co-ordination have been shown to be retarded during this period (8, 11, 12, 18). Since the tournament teams are selected toward the end of the Little League season on the basis of playing ability, it is logical that the boys who are making the puberal adjustment in motor performance are not selected because of their "awkwardness."

This study illustrates the fallaciousness of grouping subjects according to chronological age, particularly if the subjects are children and, more important, if these children are approaching the age of adolescence. According to their chronological ages the subjects in this study would have been classified as pre-adolescent when, in actuality, the majority of them were adolescent.

Summary and Conclusions

The physiological maturity of the 112 boys who participated in the 1955 Little League World Series was determined by means of the Crampton pubic hair index. Comparisons were made between pubescent status and: (1) age, height, and weight; (2) race; (3) defensive position; (4) batting order.

It was found that:

1. The majority of boys who played in the 1955 Little League World Series, according to pubic hair ratings, were adolescent and not, as their chronological ages would indicate, pre-adolescent.

2. Only 17 per cent of the boys were pubescent, whereas 45.5 per cent were postpubescent and 37.5 per cent were prepubscent. This suggests that the ability to play baseball is affected by the puberal spurt in growth.

3. The height and weight of the postpubescent subjects were equal to the height and weight of an average 14-year-old boy.

4. Five of the six Negro boys were postpubescent.

5. All eight pitchers who started World Series games were postpubescent, except one who was pubescent. The only other positions in which there was a pattern in relation to pubescent status was at first base and left field, where six of eight players were postpubescent.

6. The greatest number of postpubescent subjects batted in the 3rd, 4th, 5th, and 6th positions in the batting order. All boys who batted in the "clean-up" (4th) position were postpubescent.

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Selection and Standardization of Strength Tests for 4-H Club Members

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Abstract

Several tests of strength were examined and the reasons for their rejection are given. The growth curves were calculated and used as the basis for standard score tables. Two tests are now being used to measure improvement in strength. These ar part of a battery of fitness tests for 4-H Club members.

MANY OF THE early tests of physical fitness were essentially strength tests. Total health is now thought of as including growth, organic fitness, motor fitness, and body protection. This last area includes first aid, safety, disease prevention, sanitation, and ability to swim.

The 4-H fitness program in Illinois includes all four areas. Furthermore, it consists of two parts (1) conditioning (2) testing. Measurement is important because interest increases as a person knows he is making progress and training is important because that is the way progress is made.

Procedure

This report is limited to the discussion of those tests which can be said to be primarily strength tests. Fifty per cent of the body weight is muscle and 84 per cent of the muscle weight is in the arms, shoulders, legs, and pelvis regions. Consequently, tests for muscle groups in these regions were used.

TESTS

In the first battery, three tests—chins, push-ups and vertical jump—were used and found to cluster as a strength factor (3) which Larson (4) named dynamic strength. Later, broad jump and arm pull were added. These are described below.

Broad Jump. The original broad jump mat was a strip of linoleoum with markings painted at one-inch intervals. A 2 x 8 inch plank was staked to the ground at the take-off mark to provide a toe-hold. The testee was given three trials and his best jump was recorded. Later, a ribbed rubber mat was substituted with 4-inch intervals. Scores were recorded by the space within which the back heel landed. Thus, each frequency class included 4 inches, and 12 to 16 frequency classes were obtained when testees were grouped by ages.

The actual average and predicted average scores for boys and girls are shown in Table 1.

TABLE 1
Broad Jump Scores for 1945-54

Age in Months	Boys			Girls		
	No.	Actual	Predicted	No.	Actual	Predicted
255	13	86.8	88.4	—	—	—
245	59	86.2	87.9	—	—	—
235	103	86.9	87.2	16	62.2	65.1
225	143	87.1	86.4	54	60.7	64.8
215	236	85.1	85.1	131	64.5	64.5
205	388	82.9	83.2	373	63.3	64.4
195	609	80.5	80.6	463	63.3	63.5
185	793	76.8	77.1	719	62.9	62.9
175	956	72.7	72.8	1055	62.0	61.9
165	1221	68.6	68.5	1433	61.3	60.9
155	1054	64.1	64.1	1738	59.5	59.5
145	1308	61.6	61.8	1671	57.2	57.7
135	1184	58.2	59.1	1705	55.2	55.5
125	923	55.9	55.8	1381	52.9	52.8

Actual scores usually show an irregular curve when plotted, especially if the number of cases in each class is small.

With the numbers shown in Table 1, the actual curves are not as smooth as one might like. To determine the difference between actual and theoretical growth, these data were fitted to isochronic equations calculated from Courtis' tables (1, 2). The best fit was to a compound, double-cycle curve for the boys data but to a single-cycle curve for the girls. These curves are shown in Figure 1. The first cycle has been extended on the boys curve to illustrate that its maximum point would be much below the actual scores.

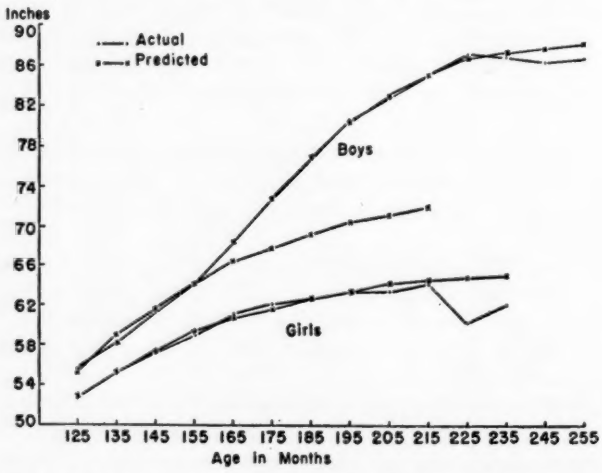

FIGURE I. The Actual and Predicted Growth Curves of Broad Jump Scores.

Courtis has found identical patterns of growth for plants, animals, humans, and social institutions. This common growth curve is a skewed curve with 50 per cent of the devolopment occurring in about one-third of the time. Thus, the last half of the curve is much longer than the first half. The equation for the growth curve is $Y = ki^{r^t}$ in which Y is the development achieved at time t, k is the value at maturity and r is the rate of growth. This equation was first derived by Gompertz. Courtis provided the transformations which, with the use of logarithmic paper, permit the calculation of the growth curves by simple arithmetic.

Growth should proceed according to a regular pattern and any modifying influences should change the shape of the growth curve. Whenever the influences controlling growth are held constant, the growth pattern follows the simplex curve, but if another set of influences comes into play, the curve is compounded, that is, another simplex curve is superimposed. Modifying influences need not always be environmental changes such as temperature, moisture, or food supply; they may be internal influences such as glandular or psychological changes. The rapid growth in strength of boys is considered the result of both internal and external modifying influences.

The absence of the second cycle for girls may be explained by the fact that social pressures toward limited physical activities have reduced training and prevented muscular development. It would seem more desirable if the growth curve for girls had a second cycle similar to the curve for boys.

The standard scores for boys and girls are shown in Tables 2B and 2G. They were calculated from distributions of three standard deviations, plus and minus the predicted mean of each age group.

Arm Pull. The arm pull machine is shown in Figure II. The testee was seated with his feet braced against the foot bar. His knees were held down without being flexed and the machine was adjusted to the length of his legs. He grasped the hand bar and pulled against the spring scales, which registered his pull in pounds. The cable was arranged so that it could be doubled for those who were able to pull over 300 pounds. The readings for those persons were doubled. Although the test is called arm pull, it tests the back and shoulder muscles too.

The actual average and predicted average scores by ages are shown in Table 3.

The scores increase by age; consequently when fitted to an isochronic growth curve, the predicted scores shown in Table 3 were obtained. The boys scores gave a compound two-cycle growth curve but the girls curve was a single-cycle only.

The standard scores were calculated from distributions of three standard deviations plus and minus the predicted mean. The standard score tables are shown as Tables 4B and 4G.

TABLE 2B

Standard Score Table: Broad Jump for Boys, 1945-54

Jump in Inches	Age in Months											
	125	135	145	155	165	175	185	195	205	215	225	235
120												99
116										99	98	96
112								99	99	95	91	89
108							99	95	95	88	85	83
104						99	95	89	86	81	78	76
100						95	89	82	79	75	71	69
96					99	88	82	78	72	68	65	63
92					91	82	75	69	65	61	58	56
88				97	84	75	69	63	58	54	52	50
84			97	89	77	69	62	56	53	48	45	43
80		99	89	81	70	62	56	50	45	41	38	36
76	99	90	80	73	63	56	49	43	38	34	32	30
72	94	81	72	65	56	49	42	37	31	27	25	23
68	84	72	64	58	49	43	36	30	24	21	18	16
64	74	63	55	50	42	36	29	24	17	14	12	10
60	65	54	47	41	35	29	23	17	10	7	5	3
56	55	45	38	34	28	23	16	11	4			
52	46	36	30	26	21	16	9	4				
48	36	27	22	18	14	10	3					
44	27	18	14	10	7	3						
40	17	9	5	2								
36	7											
No.	923	1184	1308	1054	1221	956	793	609	388	263	143	103
Mean	53.8	58.1	61.5	64.2	68.6	72.6	76.6	80.2	83.1	85.4	87.1	88.3
S.D.	6.95	7.43	7.98	8.42	9.52	10.16	10.10	10.21	9.71	9.88	10.03	10.07

TABLE 2G

Standard Score Table: Broad Jump for Girls, 1945-54

Jump in Inches	Age in Months									
	125	135	145	155	165	175	185	195	205	21
100										
96									99	
92							99		93	99
88				99	99	99	97	99	87	91
84			99	97	95	92	90	96	81	84
80		99	96	90	88	84	83	88	75	77
76	99	93	88	82	80	77	75	81	68	70
72	94	84	79	74	72	69	67	73	62	63
68	85	76	71	66	64	61	60	58	56	55
64	75	67	63	58	56	54	52	50	50	48
60	66	59	55	50	48	46	44	42	44	41
56	57	50	46	42	40	39	37	35	38	34
52	48	41	37	34	32	31	29	27	32	27
48	38	33	29	26	24	23	21	19	25	19
44	29	24	21	18	16	16	14	12	19	12
40	20	16	12	10	8	8	6	4	13	5
36	11	7	4	2						
32	2	1								
No.	1381	1705	1671	1727	1433	1033	719	63.5	373	133
Mean	52.8	55.5	57.7	59.5	60.9	61.9	62.9	463	64.1	64.5
S.D.	7.23	7.75	7.92	8.33	8.37	8.73	8.68	8.68	10.82	9.24

FIGURE II. The Arm-Pull Machine Used To Measure the Strength of the Arms and Upper Muscles.

TABLE 3

Strength Scores: Measured on Arm-Pull Machine in Pounds

Age in Months	Boys			Girls		
	No.	Actual	Predicted	No.	Actual	Predicted
245						
235	53	326	318			
225	82	318	317	27	194	199
215	121	300	308	69	197	196
205	162	295	294	141	194	193
195	266	276	278	259	188	188
185	368	249	255	374	181	183
175	433	229	228	569	178	176
165	530	204	204	749	170	169
155	628	189	187	946	160	160
145	700	174	175	939	149	149
135	610	160	163	949	137	137
125	493	150	150	760	131	124

TABLE 4B

Standard Score Table: Arm Pull for Boys, 1949-54

Pull in Pounds	Age in Months									
	125	135	145	155	165	175	185	195	205	215
440										95
420								94	93	88
400							97	87	87	82
380							91	81	80	75
360						95	84	75	73	68
340						88	78	69	66	61
320					94	81	71	63	59	54
300				95	87	75	65	57	52	47
280			95	87	79	68	58	51	45	41
260	98	94	87	79	72	61	52	45	38	34
240	89	85	78	71	64	54	45	38	31	27
220	81	76	69	63	56	47	39	32	24	20
200	72	67	61	55	49	40	32	26	17	13
180	63	58	52	47	41	34	26	20	10	6
160	54	49	44	39	33	27	19	14	3	
140	46	40	35	31	26	20	13	8		
120	37	31	26	23	18	13	6			
100	28	21	18	16	11	6				
80	19	12	9	8	3					
60	11	3	1							
40	2									
No.	493	610	700	628	530	433	368	266	162	121
Mean	149.8	162.6	175.0	186.8	203.6	228.0	255.2	277.8	295.0	307.6
S.D.	38.08	36.56	38.58	42.00	43.70	48.84	51.32	54.32	47.94	48.70

TABLE 4G

Standard Score Table: Arm Pull for Girls, 1949-54

Pull in Pounds	Age in Months								
	125	135	145	155	165	175	185	195	205
280						96	99	93	92
260				95	94	87	89	84	82
240			95	86	84	78	79	74	73
220	97	94	85	77	75	69	69	65	63
200	88	83	75	68	65	61	59	56	54
180	78	73	65	59	55	52	49	46	44
160	68	62	55	50	46	43	39	37	34
140	58	51	46	41	36	34	29	28	25
120	48	41	36	32	26	25	19	18	15
100	38	30	26	23	17	16	9	9	6
80	28	19	16	14	7	7			
60	19	9	6	5					
40	9								
No.	760	949	939	946	749	569	374	259	141
Mean	123.8	137.4	149.0	159.8	168.8	176.4	182.8	188.0	192.6
S.D.	33.84	31.32	33.54	37.36	35.56	37.44	33.36	35.72	34.68

Vertical Jump. The vertical jump differed from Larson's procedure as follows: A slate blackboard was erected with the lower edge about 6 feet high. It was ruled in one inch intervals. The jumper moistened his fingers in water, reached to mark the board, then jumped and touched the board again. His score was the difference between the marks.

In order to account for differences in the weights of jumpers, a Toledo platform scale Model 31-1822 was used as the jump platform. The jumper was weighed and the force exerted at the time of his leap was recorded. The difference in pounds was correlated with the height jumped ($r = .65$). By analysis of variance, the data in pounds was found more reliable between replicated measures on succeeding days. The best scores were made by the middle-class body types as determined by $3\sqrt{\text{Wt}}/\text{Ht}$.

This test was discontinued in favor of the broad jump because it demanded more equipment and more skill.

Chins. The number of times a testee could chin himself from a full arm's hanging position was counted as his score. The scores for 1032 boys showed that 7 per cent failed to score, and for 200 girls 51 per cent could not chin themselves once. This indicated that the test was too difficult. The distributions are shown in Figures III and IV.

Realizing that strength usually undergoes a rapid increase after about 180 months, a separate curve was plotted for boys over 185 months in age. This curve in Figure III shows a rather smooth S-shaped ogive. A Chi square test for this group gives a $P = .8$ showing a reasonably good fit to the normal distribution. The distribution was then divided at 165 months and plotted. The two parts are shown in Figure III. Over 21 per cent of the boys 125 to 155 months failed to score.

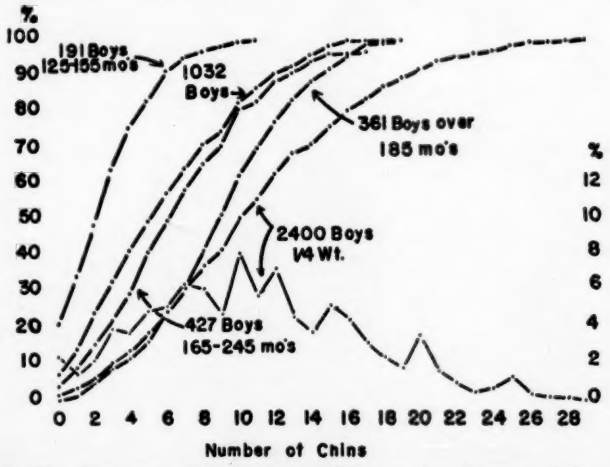

FIGURE III. The Percentage Distributions of Various Age Groups of Boys on Two Different Chin Tests.

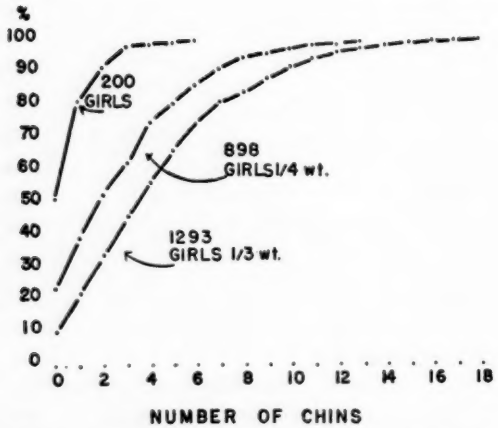

FIGURE IV. The Percentage Distributions of Girls' Scores on Three Different Chin Tests.

The test was made easier so that all ages could score by counter balancing a set of weights through a system of ropes and pulleys. (See Figure V) One-fourth the weight of each boy was counterbalanced. Thus, each had to lift only three-fourths his body weight. With this test, nearly every boy made a score but the upper end of the curve was greatly extended. In fact, 5 per cent

FIGURE V. The Chin Apparatus with One-Fourth the Boy's Weight Counterbalanced.

of the boys scored over 22 chins. Two curves—one non-cumulative, the other of cumulated percentages—are shown for 2,400 boys in Figure III. From these data, it would seem that the test had become an endurance test.

With the original chins test, 24 per cent of the girls failed to score. When one-third of their weight was counterbalanced 10 per cent still failed.

The age distribution of mean scores for boys fits the isochronic growth curve satisfactorily when boys were required to lift only three-fourths of their weight. The curve for the girls was a poor fit; it showed a loss in chinning scores after 165 months of age. In fact, the retrogression was to below the 10-year-age average. This seems to be an undesirable situation from the point of view of fitness.

The chins test with the weights and pulleys was especially interesting to the testees. It is recommended as a training device rather than a test, on the basis of being too difficult for the younger boys.

Push-ups. From a hand-stand position on the ends of parallel bars the testee lowered himself to a right-angle arm-bend position. Then he pushed his body up to the first position. He continued to lower and raise himself as many times as possible without resting.

This test was about the same in difficulty as the chin test without weights. About 21 per cent of all boys failed to do one push-up and 5.7 per cent of those 165 months and over failed. Forty per cent of the girls failed. The correlation between this test and chins was $r = .56$.

Because there was no way to make this test easier, it was abandoned as a strength test for younger age groups.

Rope Climb. The time required to climb 20 feet up a vertical rope was recorded as the score. So many were unwilling to try the test that the height was reduced to 10 feet. Even so, 15 per cent of the boys and 65 per cent of the girls who did try failed. Because of this and the danger of rope burns and the fear of falling, the test was abandoned.

Conclusions

Strength is an important factor in fitness. Tests of dynamic strength probably have more value than tests of static strength. Broad jump, chins, push-ups, and rope climbing are tests of dynamic strength but three of these were rejected as too difficult, too hazardous, or too complicated to administer.

A dynamic test for arms and shoulders is needed in a battery of fitness tests. A rotor type of machine which could be turned 5 to 30 times by testees ranging in age from 10 to 20 would seem satisfactory.

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(Submitted 10/21/55)

Standardization of Flexibility Tests for 4-H Club Members

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Abstract

This paper describes methods for testing tests of flexibility. One test was found to be too easy, the other to be more a measure of size than flexibility. Both defects were corrected so that the tests could be used as measures of improvement. Standard score tables for both boys and girls were calculated. The tests are used as part of a battery of fitness tests in the 4-H health program.

HEALTH IS ONE of the four *H's* and an important objective of the 4-H Clubs in Illinois. Physical fitness is considered an important aspect of health, and flexibility a part of fitness. The fitness program for Illinois 4-H Clubs has been described elsewhere (3). This report describes the design and standardization of the flexibility tests used to determine the present level of and the progress made in developing flexibility.

Procedure

The trunk was selected as the area of measurement for flexibility, because of its importance in posture and breathing (1) and because of the general need for developing tonus in the muscles of the back and neck (6). There are many references to weak back muscles in fitness literature (2, 4, 5). The original tests and their revisions are discussed below.

TESTS

Trunk Forward. The original instructions were: "Sit on the ground, extend your legs, lace your fingers behind your neck, and try to touch your forehead against the ground. Two partners will hold your knees down. With his right hand, your leader will hold a yardstick upright on the ground. He will point his index finger toward your eyebrows. By sliding his hand down the stick as you bend forward in order to keep his finger on a level with your eyebrows he will measure the distance by which you miss touching the ground. Scores are recorded in inches, a zero being the best score."

The accumulated percentage distribution for 1943-44 are shown in Figure I. This shows a concentration of scores at the zero point for girls which indicated that the test was too easy. The test was revised by requiring the testee to sit on a two-inch board with legs extended and with his heels exactly 18 inches apart. The curves for 1945-46 show the revised test to be more satisfactory as a test. Later, an ordinary carpenter's flexible steel tape (without a spring wind) was substituted for the yardstick. Two inches was cut off from the end and a small pad which fitted across the bridge of the nose at

the eyebrows was attached. As the testee bent forward, he pushed the tape back into its case.

The test scores did not show a trend by age or by body type ($3\sqrt{Wt/Ht}$) except that the middle (more athletic) type boys were slightly less flexible. It was noticed in administering the tests that the older, stronger, harder muscled boys were less flexible. They appeared to be muscle-bound and in need of stretching and bending exercises.

When the distributions were tested against binomial normal distributions the Chi square tests showed poor fits for both curves in 1943-1944 and 1945-48. The accumulative percentage distributions for 1945-54 and the binomial $(.5 + .5)^{24}$ are shown on Figure I by *x's*. The distribution is skewed toward the poorer end of the scale. This type of skew is characteristic of the other fitness test distributions, too.

The standard scores for the 1945-54 data are in Table 1. Standard scores were calculated with mean at 50 and the distribution extending + and — three sigmas from the mean.

TABLE 1

Standard Scores for Trunk Forward

Score in inches	Boys	Girls
0	—	—
1	—	98
2	—	93
3	99	88
4	95	84
5	89	79
6	84	74
7	79	69
8	74	64
9	69	60
10	63	55
11	58	50
12	53	45
13	48	40
14	42	36
15	37	31
16	32	26
17	27	21
18	22	16
19	16	12
20	11	7
21	6	2
22	1	
Persons tested	9201	10807
Mean	11.45	10.99
Standard deviation	3.19	3.47

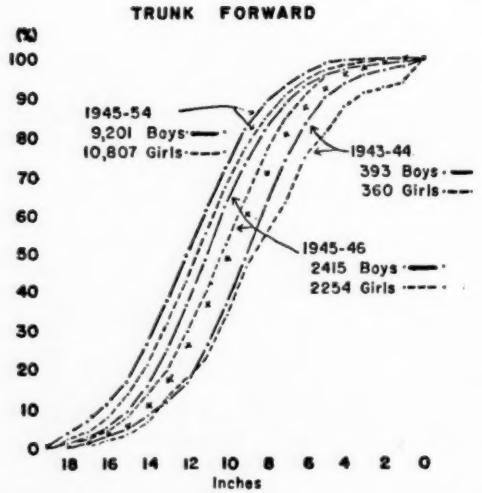

FIGURE I. Accumulated Percentage Distributions for Trunk Forward Scores.

Trunk Backward. The original instructions were: "Lie face down on the ground with your fingers laced behind your neck. Your partner will kneel at your feet and hold your legs down by grasping your ankles. By holding a yardstick in his hand in the same manner as in trunk forward, your leader will measure the greatest height to which you can raise your chin."

The scores on this test described an *S*-shaped curve which became smoother as the number of cases was increased. The smooth curve was similar to the 1945-54 curve in Figure I, and this indicated that the test was about right in level of difficulty for the group tested. The scores for boys showed increases when averaged by age groups. This did not seem reasonable.

Consequently, data from this test were placed in a factor matrix along with other fitness tests and segregated with growth measures such as age, height, and trunk length. This made it seem that the test was measuring size rather than flexibility.

As the result of the factor analysis, the method for measuring was changed. The protractor shown in Figure II, was built to measure the angle rather than the leg of the triangle opposite it. The apex of the angle was placed at the large trochanter joint. The arc was measured through the center of the ear by a small wand attached to a cord which was held at tension by the coil spring on the protractor. The units on the protractor were scaled 1 to 34 to be similar to the former measures in inches. The center of the ear instead of the chin was used at the landmark to avoid as much as possible including the rotation of the head. The method of measuring is shown in Figure III.

The revised test showed no trend by age, and it gave a smooth *S*-shaped curve when accumulated frequencies were plotted. From these data, the standard score tables shown in Table 2 were calculated.

The standard score tables show that girls average higher than boys. The observations of the testers indicate the older, hard-muscled boys generally lack in flexibility, and they recommend stretching and bending exercises as a remedy.

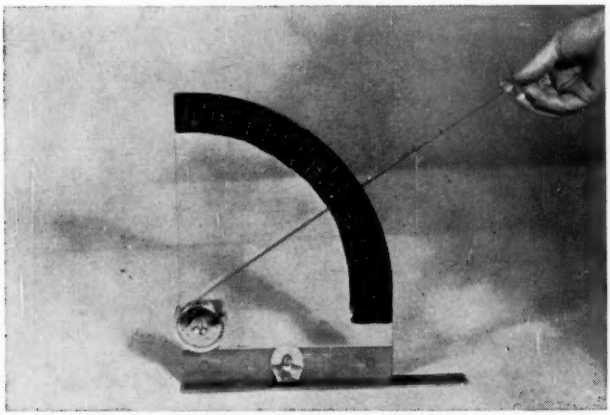

FIGURE II. The Trunk Backward Protractor.

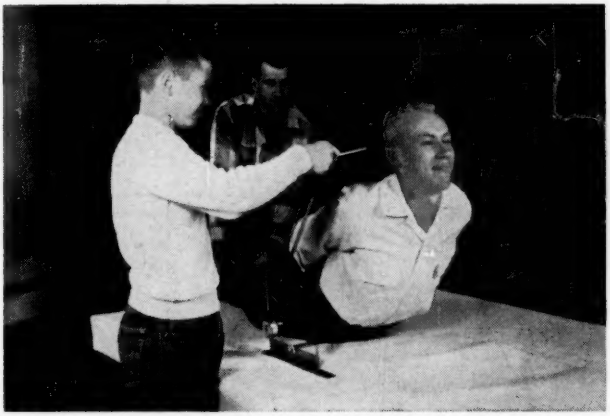

FIGURE III. The Method of Measuring Trunk Backward.

TABLE 2
Standard Scores for Trunk Backward

Score in inches	Boys	Girls
32	—	99
31	—	96
30	—	92
29	—	88
28	99	84
27	95	81
26	90	77
25	85	73
24	80	69
23	75	65
22	70	61
21	65	58
20	60	54
19	55	50
18	50	46
17	45	42
16	40	39
15	35	35
14	30	31
13	25	27
12	20	23
11	15	19
10	10	16
9	5	12
8	0	8
7		4
Persons tested	4000	4808
Mean	18.04	19.03
Standard deviation	3.30	4.37

These two tests are part of the 21 tests and measurements made on Illinois 4-H boys and girls as a part of their fitness program.

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Construction of Knowledge Tests in Selected Physical Education Activities for College Women

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Abstract

In this study, knowledge tests suitable for use in the college women's instructional program were constructed for badminton, basketball, bowling, field hockey, softball, tennis, and volley ball. All tests consisted of four-choice multiple-choice type items. Tests were administered to students enrolled in colleges and universities throughout the United States. On the basis of an item analysis each test was revised. An analysis of the final form of each test indicated that they were all satisfactory measures of knowledge in their respective fields.

THE ACQUISITION of knowledge is generally recognized as an important outcome of most physical education programs. One technique for determining the extent to which knowledge content is being learned is a written test. While written tests may and should be used for motivation, practice in applying knowledges, and for discovering pupils' level of ability at the beginning of a course, it is for evidence of progress or achievement that they are most universally used. If attainment of objectives is to be accurately and fairly evaluated on the basis of progress and achievement, skillfully constructed teacher-made or standardized tests must be used.

In standardized tests emphasis is placed on the amount and relative importance of various phases of knowledge. This fact may limit their use, however, when the emphasis in specific courses differs to any appreciable extent. There is cerainly, however, an advantage in selecting standardized tests over poorly constructed teacher-made tests in that these tests usually give supporting evidence of reliability and validity as well as norms for specifically defined educational levels.

Since relatively few tests in physical education have been made available in periodical literature and since none of the test-construction agencies have prepared tests for physical education, teachers are forced to construct their own tests regardless of the adequacy of their preparation or to rely on those that have been constructed primarily for use in specific situations.

That physical educators recognize the need for assistance in the area of knowledge test construction was evidenced by discussions at the 1951 Lake Geneva Workshop of the National Association for Physical Education of College Women. At that conference many of the participants, all of whom were college physical education instructors, expressed a need for and an interest in

standardized sports knowledge tests suitable for use in the college instructional program. It was a report of these discussions that stimulated the writer to undertake this study.[1]

Purpose

The purposes of this study were: 1. to construct and standardize, on the basis of sound criteria for test construction, knowledge tests in badminton, basketball, bowling, field hockey, softball, tennis, and volleyball suitable for use in the physical education instructional program for college women; 2. to establish percentile norms for these tests based upon test results of large numbers of women students enrolled in colleges and universities throughout the United States.

Procedure

Preliminary to the construction of the knowledge tests, an analysis of textbooks and printed source materials for each sport was made. Since a textbook analysis alone would be insufficient to insure curricular validity of tests, this analysis, supplemented by the writer's teaching experience in all of the sports, was used as the basis for the construction of checklists to be used in a survey of course content. These checklists, devised for all of the sports except tennis, covered material under such topic headings as history of the sport, individual skills or techniques, team tactics, selection and care of equipment, safety, terminology, etiquette, and rules. Tennis was not included in the checklists constructed for use in this study since the results of a similar study had just been made available by Bartley (4).

In the fall of 1951, checklists were sent to 117 colleges and universities. These schools were selected to include a widespread geographical distribution as well as representation from public and private institutions, coeducational colleges and universities, and teachers colleges. The analyses from the returned checklists of the percentage of time devoted to each general category in each course served as the basis for the establishment of a table of specifications for each test. A further analysis of the material included in courses in each sport aided in the determination of item content for the tests.

The multiple-choice type item was selected for use in this study since, according to French (6,p.*410*), it seems to be adaptable to most of the subject matter in physical education, can be objectively scored and adapted to the use of answer sheets, makes the task of detecting non-functioning distractors easy, and tests the student's ability to eliminate incorrect responses as well as to select the correct answer.

Between 50 and 60 four-choice items were constructed for each test. The arrangement of the items as well as the placement of the choices, was determined by random selection. The completed tests were submitted for criticism and suggestion to graduate students enrolled in a measurement

[1]This study was made in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate College, State University of Iowa, 1955.

seminar. These students were experienced teachers in all of the sports. The suggestions of this group were incorporated in the final revision of the original forms of the tests.

In the fall of 1953, letters were sent to the chairmen of 44 colleges and universities who had indicated at the time of the survey of course content that they would be willing to administer tests to their students. Included with the letter was a test list form on which the administrator was asked to indicate the activities in which tests would be given, the number of tests needed, the approximate date the tests would be administered and the name of the person to whom the tests should be sent.

Mimeographed copies of the examinations, answer sheets, and directions for the test administrator were sent far enough in advance to insure arrival by the date that they were to be given.

All completed answer sheets were hand-scored as soon as possible after their return. It was assumed that students who did not attempt the last four items of the test had not had time to complete the test so their papers were discarded. Results of the test for each student as well as the range, mean score, and standard deviation of the distribution for all students of that institution were sent to each instructor immediately following the grading of the papers.

The Flanagan technique was utilized in the analysis of the field hockey and softball tests. This technique utilizes the papers of the 27 per cent who made the highest scores on the test plus the lowest 27 per cent of the papers. The responses to all items are recorded for both the upper and lower groups. The correlation coefficient which corresponds to the proportion of the upper and lower 27 per cent correctly answering the question is the index of discrimination. This index is easily obtained from the table of indices prepared by Flanagan (9, pp. 290-291). By use of this technique both the difficulty rating, and the presence of non-functioning distractors are readily obtained. In this study a distractor was considered as non-functioning when selected on less than 3 per cent of the papers.

In the analysis of the remaining tests the Aschenbrenner (3) technique was used. This technique which can be used when large numbers of papers are to be included in the analysis is based upon the upper and lower 10 per cent of the papers in the distribution.

On the basis of the item analysis, items were discarded which fell outside of the range ten to 90 for the difficulty rating. All items with an index of discrimination below 16 were also eliminated. In addition, any item with less than two functioning distractors was discarded.

The remaining items were selected for inclusion in the final form for each test according to the table of specifications. In cases where there were more items than were needed for a particular category, the content of the item plus the discriminating power served as the deciding factor The revised forms of the tests contained from 33 to 37 items.

New keys were constructed on the basis of the items included in the final forms of the tests and all papers were re-scored.

Angoff's Equation C, and adaptation of Kuder-Richardson formula #8, was used for estimating the coefficients of reliability for all of the tests. This formula, $r_{tt} = \frac{\sigma_t^2 - \Sigma pq}{\sigma_t^2 - \Sigma r_{tt}^2 pq}$, assumes, as does Kuder-Richardson #8, homogenity of content of material included in the tests. The values of the "true" variance($r_{tt}^2 pq$) were taken from the "Table of Values Used in Computing Alpha Reliability Coefficients" prepared by Ebel. Although this table was constructed for the upper and lower 27 per cent groups, and the indices of discrimination for the items on the majority of the tests in this study were figured on the basis of the upper and lower 10 per cent, the differences did not appear to be great enough to exclude the use of this table.

The final form of each test was compared with the standards for classroom tests established by Ebel (5, *p.4*). These standards which include relevance, discrimination, and time limitation served as a further basis for test evaluation.

On the basis of the distribution of scores on the final or revised forms of the tests, norms in the form of percentile ranks were computed for each of the seven tests.

Analysis of Data

As a preliminary step to the construction of seven knowledge tests in selected physical education activities for college women, a survey of course content was made. Checklists were completed and returned from 97 of the 117 institutions which were contacted. Not every institution was represented by a checklist in each activity.

An analysis of the checklists was used to establish a table of specifications for each activity test. This material was combined and is presented in Table 1.

TABLE 1

Tables of Specifications for Tests in Badminton, Basketball, Bowling, Field Hockey, Softball, Tennis and Volleyball

Course Content	Badminton	Basketball	Bowling	Field Hockey	Softball	Tennis	Volleyball
History of sport	1*	1	2	2		3	1
Equipment	5			4		2	
Etiquette	4		8				
Skills and techniques	55	48	51	59	45	50	51
Playing strategy	19					35	
Team tactics		29		20	25		33
Rules and scoring	16	22	27	15	20	10	15
Terminology			11		10		

*All numbers indicate approximate percentage of time spent on each general category in courses in the various sports.

As is indicated, the major emphasis in courses, regardless of activity, was on skills and techniques. In all activities except bowling, team tactics or playing strategy ranked second. Rules and scoring were next with from 10 to 27 per cent of the time spent in this area.

Affirmative replies were received from 30 or 70 per cent of the 44 department chairmen who were asked to co-operate in administering tests to their students. Not all tests could be administered in all schools. More tests were given in tennis, bowling, and badminton, the individual sports, than in any of the team sports. Table 2 shows the number of students who took the test, the number of questions, mean, standard deviation, and range of scores for

TABLE 2

Mean, Standard Deviation, and Range of Scores on Original and Final Forms of Tests

Criterion	Badminton	Basketball	Bowling	Field Hockey	Softball	Tennis	Volleyball
No. of cases	1432	538	1618	1088	208	2291	953
No. of questions							
Original	59	50	43	40	50	49	58
Final	37	35	35	32	33	35	35
Mean							
Original	34.92	29.60	27.30	20.99	25.84	30.94	34.36
Final	18.77	21.92	21.20	18.21	17.15	22.90	21.30
Standard deviation							
Original	6.26	5.10	5.22	4.62	5.39	5.22	5.97
Final	4.80	4.51	4.88	4.76	5.06	4.59	4.69
Range of scores							
Original	14-53	12-44	10-41	9-35	13-44	14-48	14-51
Final	5-34	8-32	7-34	6-32	7-30	8-35	8-33

each of the original and revised forms of the tests. These data will probably be more meaningful if each test is considered separately.

BADMINTON TEST

The badminton test was taken by 1,432 students from 24 different colleges. On the original form of the test there were 60 items. Item number 48 was marked off before the tests were sent out because of a typographical error in the test booklets.

The range of scores on this original form of the test was from 14 to 53. The mean score for students from each institution was calculated with results varying from 28.30 to 41.86. The mean score for all students on this form was 34.92.

As a result of an item analysis of the 59 items, five were eliminated because of low indices of discrimination, and one because it had too few functioning distractors. Sixteen other items, satisfactory in every respect, were omitted so that the proportion of items included in the test would meet the table of specifications. The final form of the test contained 37 items. Scores ranged from 5 to 34, with the mean score being 18.77.

BASKETBALL TEST

The basketball test, containing 50 items, was administered to 538 students enrolled in 16 colleges and universities. Before items were eliminated, the mean score was 29.60, with scores ranging from 12 to 44.

On the basis of the item analysis, seven items were discarded. Five of these had low discriminatory power, one was too easy, and the other too difficult. Eight other items, satisfactory from the standpoint of difficulty and discriminatory power, were excluded when items were selected to meet the specifications for the revised test. On the revised form of 35 items, scores ranged from 8 to 32, with the mean score being 21.92.

BOWLING TEST

A total of 1,618 students from 15 institutions took the bowling test. Scores on this test ranged from ten to 41 out of a possible 43. The mean score was 27.30.

The item analysis of the test revealed the necessity of eliminating five items. Two of these five items lacked sufficient functioning distractors; the other three were eliminated because of low indices of discrimination. Only three other items were excluded in order to meet the percentage requirements of the table of specifications. With 35 items remaining on the revised test, the mean score was 21.20. Scores ranged from 7 to 34.

FIELD HOCKEY TEST

The original field hockey test contained 40 items. The range of scores for the 1,088 students from 18 schools who took this test was from nine to 35. The mean score was 20.99.

As a result of the item analysis, eight items were eliminated from the final test due to low indices of discrimination. The remaining 32 items satisfied the requirements of the table of specification, and, therefore, were retained. The scores on the final form of the test ranged from 32 to 6 with 18.21 being the mean score.

SOFTBALL TEST

Only 208 students representing seven different institutions were able to take the softball test. With 50 being a perfect score, the scores varied from 13 to 44, with 25.84 representing the mean score.

The item analysis of test results revealed that seven items should be dropped because of either difficulty ratings that were too low or the lack of ability to discriminate between good and poor students. Eight other items were not used in the revised test even though the analysis had indicated that they were satisfactory. The remaining 33 items yielded a range in scores from 7 to 30. The mean score for this group of students was 17.15.

TENNIS TEST

This test was administered to 2,291 students, enrolled in 25 different colleges. Scores ranged from 14 to 48 out of a possible 49. The mean score for the total group was 30.94.

Nine items were found to be inadequate as a result of the item analysis. In an attempt to have the content of the test meet the standards as established by the table of specifications five other items were not used in the final test. With 35 items included in the test, the mean score was 22.90. The range in scores was from 8 to 35.

VOLLEYBALL

The test in volleyball was administered in 18 colleges to 953 students. A mean score of 34.36 was obtained on the initial form of the test, which consisted of 58 items.

Eleven items were found to be unsatisfactory as a result of the item analysis. Since there were too many items concerned with rules and scoring, 12 additional items were omitted from the final form of the test. Thirty-five items were used in the revised test. Scores made on the test varied from 8 to 33, with a mean score of 21.30.

A comparison was made between the original and revised form of each test. This comparison indicated that with the exception of badminton there was little change in the difficulty of the tests when they were shortened. The badminton test was made more difficult by the elimination of relatively easy items, and those with too few functioning distractors.

In all of the tests, the discriminating power was increased by the exclusion of some 50 items with indices below .20. Of the seven items which were retained with an index below .20, none was below .19.

Estimates of reliability were calculated by Angoff's Equation C. The test with the highest reliability was the softball test with a .81, while the badminton test with a .72 had the lowest reliability. The fact that none of the reliabilities were higher may well have been due to the length of the tests (no test contained more than 37 items) and the fact that those students taking the test had extremely varied backgrounds. The variation in course length from 8 to as many as 54 lessons is an indication of heterogeneous experience.

In Table 3 a comparison is made between obtained means, standard deviations, reliabilities, and item discrimination of the tests and standard values based upon those of the Examinations Service of the State University of Iowa. The obtained means of the badminton and softball tests are slightly below the expected values for these two tests. Since these two tests also had the lowest difficulty ratings of all of the tests, it is probably an indication that there are some items too difficult to be effective. The standard deviations of all tests, however, compare favorably with the standard values as do the reliabilities. With regard to item discrimination, in only two instances do the data from the tests fail to meet the specifications of the standard value. Neither the badminton test nor the volleyball test has the required percentage of items in the high discrimination category. This deviation from the standard is so small, however, that both tests would be considered satisfactory in this area.

TABLE 3

Comparison of Mean, Standard Deviations, Reliabilities, and Item Discrimination of Revised Forms of the Tests with Standard Values[1]

Items compared	Badminton	Basketball	Bowling	Field Hockey	Softball	Tennis	Volleyball	Standard Value[1]
Mean	18.77	21.92	21.20	18.21	17.15	22.90	21.30	
Standard value	23.13	21.88	21.88	20.00	20.63	21.88	21.88	
Standard deviation	4.80	4.51	4.88	4.76	5.06	4.60	4.69	
Standard value	4.63	4.38	4.38	4.00	4.13	4.38	4.38	
Reliability	.72	.76	.76	.79	.81	.73	.75	more than .70
Item discrimination								
High (.41 and up)	22[2]	37	37	74	49	29	23	more than 25%
Moderate (.21 to .40)	73	60	57	26	42	71	77	more than 25%
Low (.01 to .20)	5	3	6	0	9	0	0	less than 15%
Zero or negative	0	0	0	0	0	0	0	less than 5%

[1]Standard values are based upon those of the Examinations Service of the State University of Iowa.
[2]Figures given for item discrimination are percentages.

Summary and Recommendations

As a result of this study, the following conclusions are drawn:

1. The badminton, basketball, bowling, field hockey, softball, tennis and volleyball tests that were constructed and standardized in this study are satisfactory measures of knowledge in their respective areas.

2. Each test in its entirety should only be used in situations where the distribution of content is in fairly close agreement with the specifications of the test.

3. Where a test is used in its entirety, the established norms may be used for comparative purposes.

4. In situations in which the entire test might not be suitable for use, it might well serve as a guide in the construction of teacher-made tests.[2]

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(Submitted 11/10/55)

[2]Any qualified instructor may obtain information concerning the availability of the tests by contacting the author.

Reliability and Validity of a Motor Ability Test for High School Girls[1]

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Abstract

This is a study to determine the reliability and validity of an adaptation of the Humiston Motor Ability Test when used with high school girls. The reliability was determined by four trials administered to Freshman and Sophomore girls. The validity was determined by two criteria. One criterion was based on performance in a battery of athletic skill tests and the second on participation in extracurricular activities. The test was found to be a reliable and valid general motor ability test for high school girls.

THERE IS always a definite need for a reliable and valid test, easy to administer and score, which can be used to classify students for instruction. When students are grouped for instruction according to a predetermined level of ability, and the teaching can be directed to this level of ability, the students should gain more from their learning experience. Closely allied with the student's learning experience is the degree of motivation. When success is experienced, motivation for continued effort is greater than if failure is always the end result of participation. A classification of students as to general motor ability could facilitate a more efficient evaluation of progress in athletic activities. Hence, this test was meant to be used for classification purposes.

Purpose

The purpose of this study is to determine the reliability and validity of an adaptation of the Humiston (3) Motor Ability Test when used with high school girls.

Procedure

The Humiston test was chosen for adaptation because it fulfilled several of the requirements believed by this investigator as requisites for a functional motor ability test. The Humiston test includes the factors of running, jumping, quick change in body position, getting over obstacles, dodging, and hand-eye co-ordination. This test can be satisfactorily administered by one teacher, it is economical of time and equipment, and the results can be recorded as a single score.

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[1]Summary of a Master's Thesis completed at the University of Washington, June, 1955.

The adaptation of the Humiston test consisted of the following progression:

1. Run through a maze of 17 chairs
2. Jump over a horse
3. Turn in a circle and continue through barriers
4. Climb and descend a perpendicular ladder
5. Pick up a ball from the outstretched hands of a student
6. Throw the ball over a rope and catch it
7. Drop the ball
8. Make a lateral roll on a mat
9. Crawl under a saw-horse
10. Run 50 feet to the finish line.

In the adaptation of the Humiston test,[2] the progression of the test was simplified and several changes were made because of the set-up of the gymnasium. For safety reasons, the test was changed so that the dash did not follow throwing the ball over the rope. In the original test, the angle of the body was off balance to the extent that it was difficult to regain balance and safely continue the dash. In the maze run of the Humiston test, there were nine chairs. Seventeen chairs were used in the Olympia test but the running pattern was simpler to follow.[3]

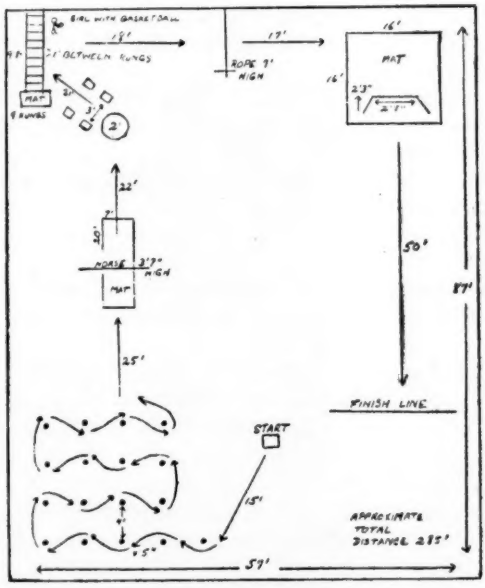

FIGURE I. Olympia Motor Ability Test.

[2]The adaptation will hereafter be referred to as the Olympia Motor Ability Test.
[3]See diagram of the Olympia Motor Ability Test (Figure I).

Validation of Test

Two criteria were used in the validation of the test. One criterion was based upon achievement in a battery of skill tests and the second on athletic participation.

ATHLETIC ACHIEVEMENT CRITERION

The athletic achievement criterion was obtained as an index of the individual's general athletic ability. After a review of the literature and a study of the work completed by some authorities in the field of testing, a battery of tests were selected because they showed a high relationship with motor ability (1, 4, 6). The battery of tests used for this criterion and the different motor ability elements involved in each were as follows:

Volleyball wall volley. This test involves skill in ball handling, eye-hand co-ordination, an understanding of angle and speed of rebound, and speed of reaction of the individual. The volleyball wall volley included a line drawn 7 ft. 6 in. high, parallel to the floor. The subject stood behind a 6 ft. restraining line and volleyed against the wall as many times as possible in 30 sec. Only those hits on or above the 7 ft. 6 in. line counted toward the score.

Basketball speed pass against the wall. The factors involved are ball handling, eye-hand co-ordination, and strength. In this test, the subject stood behind a ten foot restraining line and passed the ball against the wall as many times as possible in 30 sec.

Standing broad jump. This test involves leg strength, co-ordination of arms and legs, and an understanding of the effort of balance with respect to the individual's body movement.

Jump and reach. This test involves leg strength, explosive power, and the ability to execute a vertical ascent.

Softball throw for distance. This test measures arm strength and leg co-ordination. The softball throw for distance was described by Scott and French (6) as the best single measure of softball playing ability.

Fifty-yard dash. This test involves leg strength, arm and leg co-ordination, and speed.

Physical fitness and endurance test. The purpose of this test was to obtain a measure of the over-all strength and endurance of the individual. This test consisted of a series of physical stunts, such as sit ups, 10-sec. leg lifts from prone and supine positions, and head and shoulder lifts from a prone position. In order to obtain the greatest possible discrimination in physical strength and endurance, the subjects were allowed to continue each test as long as possible. The number of consecutive times each stunt was performed was recorded as the score and the summation of the number of repetitions on all items was their total score. Student assistants timed and scored each test.

The reliability of the physical fitness and endurance test was not determined by this investigator; hence, it was used as a part of this criterion with some reservation.[4]

[4]Further details on the set-up of the tests and their reliability and validity can be found in the original study.

T-scales were constructed for each of the above tests, and the sum of the T-scores for all tests was called the composite athletic achievement criterion score.[5] For the motor ability test, the better score of the first two trials was used for statistical calculations and comparisons throughout the entire study. The scores on the motor ability test were correlated with the following AAC: (See Table 1.)

AAC 1. Total T-score of the AAC, without the physical fitness test and 50-yd. dash (125 cases).

AAC 2. Total T-score of the AAC, including the dash and without the physical fitness test (55 cases).

AAC 3. Total T-score of the AAC, including the dash and physical fitness test (55 cases).[6]

AAC Correlations. It is generally agreed that to be proficient in a variety of athletic skills an individual must have a high degree of general motor ability. Conversely, when an individual performs at a lower level of accomplishment in a variety of athletic skills, it is expected that the individual has less general motor ability. When the motor ability test scores are correlated with the athletic achievement criterion, a moderately high correlation is found with the criterion of general athletic ability. (See Table 1.)

TABLE 1

Correlation Between the Motor Ability T-Score and the Various AAC Criteria

Criterion	Number of Cases	r	P.E.
AAC 1	125	.6910	.031
AAC 2	55	.7979	.033
AAC 3	55	.7988	.033

When the AAC is considered without any measure of running speed (AAC 1), the correlation with the motor ability test is only .69. The addition of the dash to the AAC (AAC 2) raises the correlation coefficient, indicating that speed is a necessary factor in this motor ability test.

The effect of the physical fitness test is negligible (AAC 3), indicating that fitness and endurance, as measured by this test, are not important factors. However, it must be remembered that strength is a factor in several of the AAC tests and this amount of strength may be a factor in the motor ability test.

Since the composite AAC is an index derived from the results of a variety of athletic skills and there is a significant correlation between the AAC and the motor ability test scores, it can be concluded that there is a definite relationship between this criterion of athletic ability and the students' motor ability.

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[5]Athletic achievement criterion may hereafter be referred to as AAC.

[6]Hereafter, these criteria will be referred to by number only.

ATHLETIC PARTICIPATION CRITERION

It was reasoned that on the whole those students with a high level of general motor ability would be likely to participate to a greater extent in the extracurricular physical education program than would those with a low level of motor ability. Therefore, participation in the extracurricular athletic program was used as a second validating criterion for the motor ability test. The following activities offered in the girls' athletic program were used to determine this participation criterion: badminton, basketball, bowling, girls' tennis team, golf, hiking, swimming, tumbling, and volleyball. All girls had an equal opportunity to obtain points and had been in school an equal number of semesters. The athletic participation score was determined by the total number of points accumulated through participation in these activities.

This athletic participation criterion[7] was compared with the score of the motor ability test. All students with at least two motor ability test scores were used in this part of the study (80 students). A distribution of motor ability test scores was made for these students. The top 30% (24 cases) made up the high motor ability group; and the lowest 30%, the low motor ability group. The mean APC score, sigma, and sigma of the mean were found for these two groups. Using the *t* test for small samples (5), the difference between these means was tested for significance.

TABLE 2

Significance of the Difference Between the Mean APC Score of the High and Low Motor Ability Groups

M.A. Level	Number of Cases	M.A. Score Range	APC Mean	σ	σm	Difference between the Means	t
High M.A.	24	34.5-38.0*	138	39.52	8.081	105	8.076
Low M.A.	24	41.1-49.5	33	28.06	5.738		

*Since this is a timed score, the low motor ability score is better.

When the mean APC score of the students shown by this test to have high motor ability scores is compared to that of those with low motor ability, it is found that the high motor ability students have a much higher athletic participation score. (See Table 2.)

The difference between the groups is significant at better than the 1-percent level of confidence. These results indicate that this test discriminates to a high degree between groups whose participation in athletic activities is markedly different.

Reliability of the Test

The test was administered on four successive days to all Freshman and Sophomore girls in the physical education classes at Olympia High School, Olympia, Washington, during the school year of 1953-54. A total of 125 students completed the test four times.

[7]Hereafter, athletic participation criterion may be referred to as APC.

The coefficient of correlation for the first and second trials of this motor ability test is found to be .428 ± .049. The correlation between the better score of the first and second trials and the better score of the third and fourth trials is .85 ± .017. The latter correlation gives a substantially higher figure than that obtained between the first and second trials. The mean is found to be 41.09; and the standard deviation, 3.52. The sigma of the mean is .33. The distribution of scores above and below the mean is approximately normal.

These results indicate that, when used on a high school level, one administration is not sufficiently reliable. It can be assumed that Olympia High School students are more variable when tested in motor ability than college women; hence, at least two trials are necessary. The better of two trials yields a satisfactorily reliable motor ability score.

Conclusions

Within the limitations of this study, the following conclusions seem justified.

1. The better of two trials on this motor ability test gives a reliable score for high school girls.
2. The test has been shown to be a valid measure of general motor ability for high school girls.

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(Submitted 9/9/55)

An Exploratory Study of the Ballistocardiogram As a Measure of Circulatory Fitness

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Abstract

The purpose of the study was to find out whether any significant differences existed between the ballistocardiograms of two groups of young male adults, one group of which (N-15) was supposedly in good condition as the result of training with endurance exercises and the other group (N-16) in relatively poorer condition as the result of sedentary living. Brachial sphygmograms and a modified Schneider test were recorded for purposes of comparison. The ballistocardiograms and the sphygmograms for the two groups did not differ significantly. The means of the Schneider Index differed at the five per cent level of confidence.

THERE IS AN ever existing need for physical educators to adopt for their use better methods of measuring circulatory fitness. Instruments which adequately reflect the differences in the circulatory condition of so-called normals are essential for the full understanding of the effects of exercise and athletic training on the human organism. Physiologists and physicians in recent years have attached considerable importance to the ballistocardiograph as a means of measuring the vigor of the heart muscle, and of diagnosing abnormal heart functioning (6, 10, 11). In view of the interest of medical researchers in this instrument, the investigators were curious about its possible usefulness as a means of indicating the circulatory fitness of normals, especially as effected by endurance exercise over a period of time.

The present investigation was undertaken (1) to explore the extent to which the wave component of the ballistocardiogram believed to most nearly reflect heart vigor differs for two groups of subjects varying, supposedly, in the kind of circulatory fitness that is associated with physical conditioning by endurance exercise, and (2) to compare the ballistocardiogram findings with those for two other currently used measures of circulatory fitness, namely, the brachial sphygmogram recorded with the Cameron Heartometer (1), and the Illinois modification of the Schneider Index (5), but with blood pressure omitted.

[1]The investigators wish to express their appreciation for the help rendered by Dr. J. E. Smith, Chief of the Medical Division of the Civil Aeronautics Administration, Washington, D. C., who very generously recorded the ballistocardiograms; and William E. Krouse, wrestling coach, University of Maryland, who provided the physically conditioned group of subjects.

The Ballistocardiograph

The theory underlying the operation of the ballistocardiograph is relatively simple. Each beat of the heart exerts sufficient force so that the entire body mass is set in motion. The ballistocardiograph records this motion. Various models of the instrument are in use. Perhaps the most convenient and widely used at the present time are those employing a light bar placed across the subject's shins when he is in the lying position. Movement of the bar is electrically transmitted to a recorder. The instrument used in this study was of this type with the bar movement picked up by a magnetic coil arrangement and recorded on a Sanborn Polyvisocardiette (9, 10). Body movement can be recorded in three ways: in terms of displacement, velocity, and acceleration. Movement generally is measured in a head-foot direction. Figure I represents a typical ballistocardiograph tracing.

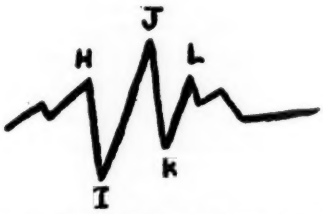

FIGURE I. Typical Ballistocardiograph Tracing.

From the physical educator's point of view the waves which seem most likely to have significance are the I and J waves. The I wave reflects a footward movement and is believed to be associated with ventricular contraction and the expulsion of blood into the ascending aorta; the J wave reflects a headward movement and supposedly is associated with the deceleration of blood in the ascending aorta and the acceleration of flow in the descending aorta (7). Starr, Rawson, Schroeder, and Joseph (11) demonstrated, using 25 subjects with normal hearts, that the stroke output as estimated from a formula based on the I and J complexes was closely related to stroke output estimated by the ethyl iodide method ($r = .86$). These investigators also demonstrated that the tracings were quite reproducible (reliable).

Procedure

SUBJECTS

The subjects for this investigation included two groups of healthy young males: one, a group of subjects well-conditioned by endurance exercises; the other, a group believed to be in relatively poor condition. All were students at the University of Maryland.

The well-conditioned group ($N = 15$) was composed of candidates for the varsity and Freshman wrestling teams. The subjects had trained by distance running and other vigorous activities five or six days a week for approxi-

mately nine weeks. The group had a mean of 5.6 years of wrestling experience; 14 of the 15 reported that they had participated in a varsity or Freshman sport in college; 13 reported having participated on an organized athletic squad in high school. It should be noted that wrestlers were chosen in preference to a group of other athletes because this particular group was reputedly in good condition. Furthermore, the investigators hypothesized that wrestling, unlike an endurance activity such as distance running, is not selective in terms of body type (12) or an innately strong circulatory mechanism, genetic factors which, undoubtedly, affect the ballistocardiogram and which the investigators wished to minimize.

The group assumed to be in poorer condition (N = 16) consisted of volunteers from the required physical education program. Three were from a general activity class; six were from a class in bowling; and seven were from weight lifting. This group had participated in their respective activities three one-hour periods per week for nine weeks. Only one of the group reported having exercised regularly outside of class, and one other reported having played a varsity sport in college (tennis). Twelve of the 16, however, indicated that they had participated on an organized team in high school. Unfortunately, volunteers for such projects are seldom in really poor physical condition, and the investigators gained the impression that this was true for this group.

SPHYGMOGRAMS

The amplitude of the initial wave (systolic amplitude) was selected for measurement. This component has been shown to be valid for differentiating athletically trained groups from comparatively untrained groups (3, 4, 8). A representative measure was obtained by locating a series of regularly formed waves of maximum amplitude and measuring the highest wave.

MODIFIED SCHNEIDER INDEX

The Schneider Index was computed in accordance with the Illinois revision of the test (5), but with blood pressure omitted. Blood pressure has been shown to contribute very little, if any, to the value of the Index for predicting endurance performance (2).

Findings

Table 1 indicates the degree to which the groups were comparable with respect to certain basic variables. Table 2 shows the differences between the means for the two groups and the statistical significance of these differences.

TABLE 1

Comparison of the Groups on Age, Height, and Weight

Variable	Wrestlers (N = 15)		Non-Wrestlers (N = 16)	
	Mean	*Range*	*Mean*	*Range*
Age (years)	20.5	19-22	19.5	18-22
Height (in.)	68.8	65.9-72.6	69.8	64.5-73.6
Weight (lb.)	160	132-185	153	130-182

TABLE 2
Significance of the Mean Difference Between the Wrestlers and Non-Wrestlers

Variable	Wrestlers (N = 15) (*Mean*)	Non-Wrestlers (N = 16) (*Mean*)	Mean Difference	*t*-Ratio
Displacement (in.)	.0031	.0028	— .0003	1.36
Velocity (mm/sec.)	2.33	2.06	—0.27	1.82
Acceleration (mm/sec.^{2})	43.2	42.9	—0.30	0.08
Sphygmogram amplitude (mm)	17.3	15.9	—1.4	1.62
Schneider Index	14.9	12.8	—2.1	2.50

NOTE: The confidence levels for the *t*-ratio with 29° of freedom are: 5% — 2.045; 1% — 2.756.

The means for all variables for the conditioned group (wrestlers) were greater than those for the nonconditioned group. The modified Schneider Index, however, was the only variable with a statistically significant difference between the means (5% level of confidence).

Both the sphygmogram and the ballistocardiogram, presumably, are influenced to some extent by the stroke output of the heart. The sphygmogram amplitude was correlated with both the displacement and velocity of the I-J complex. The coefficients obtained were .22 and .31 respectively (N = 31). Neither of these are statistically significant at the 5 per cent level of confidence.

Conclusions

The investigators conclude on the basis of the analysis of the data and personal observations made during the course of the study that the ballistocardiogram at its present stage of development is not sufficiently sensitive to reflect differences in circulatory fitness of the kind represented by the two groups of subjects used in this study. The instrument is still in the developmental stage and further research is needed. Studies should be conducted to determine the influence of tissue density, body type, position of the heart, and exercise on the ballistocardiogram.

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(Submitted 10/3/55)

Roentgenographic Measures of Leg Muscle Size and Ankle Extensor Strength of Seven-Year-Old Children[1]

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Abstract

The purpose of this study was (1) to determine the relationship between roentgenographic measures of muscle size of the leg and ankle extensor strength of 51 seven-year-old children, and (2) to examine sex differences in strength and leg muscle size at this age level. The correlations between ankle extensor strength and the measures of leg muscle size ranged between .58 and .63 for the boys and between .22 and .52 for the girls. The boys were substantially stronger than the girls in ankle extensor strength ($P = .02$) and possessed on the average the greater muscle size. When boys and girls were paired on the basis of measures of muscle size, the superiority of the boys in strength was significant at only the 30-per-cent level of confidence.

WITHIN THE LAST two decades, soft tissue roentgenograms have been used in observing changes in the distribution of the tissue components during the growing years. Studies using this procedure have clearly demonstrated that measures of the external dimensions of the body are often misleading, for children of similar external proportions may differ markedly in the distribution of bone, muscle, and subcutaneous tissue.

Among the first to use roentgenograms in studying tissue growth of young children was Stuart (10, 11) at Harvard, who used anteroposterior views of the calf from which measures of areas and breadths of the tissue components were taken. Data from the Harvard studies showed that from the first to the sixth year of life the per cent of bone and muscle tissue increased rather steadily with a proportionate drop in subcutaneous tissue. Furthermore, the data revealed that at all age levels the boys had a relatively higher percentage than the girls of bone and muscle tissue with a smaller proportion of fatty tissue. Later, Reynolds (9) using radiographic methods in a longitudinal study of children 6 to 12 years of age found that the more muscular children tended to be relatively short and light in weight, while those with a relatively thick layer of subcutaneous tissue were generally the taller and heavier children. More recently Garn (3) and his co-workers have shown substantial correlations between roentgenographic measures of muscle size of the leg

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and basal metabolism. On the basis of his findings, Garn has tentatively suggested the use of muscle size as a metabolic reference standard.

These studies have given valuable information concerning the pattern of growth of the tissue components, although the techniques have provided little data relative to the physiological condition or the functional power of muscle tissue. Information on the strength of muscle tissue per unit of cross-section is available from studies on excised animal muscles, from work performed on the muscles of human amputees, and from studies on normal adults in which indirect methods of computing muscle size and muscle attachment have been utilized (7, 8). Limited data are also available on the strength of individual muscle groups in young children, but no attempt has been made to examine the muscular strength of children in relationship to measures of muscle size (5).

The purpose of this study was (1) to determine the relationship between ankle extensor strength and roentgenographic measures of muscle size of the leg of a group of seven-year-old boys and girls, and (2) to determine sex differences in strength and leg muscle size at this age level.

Procedure

Subjects. The subjects for this study included 32 boys and 19 girls, all American-born white children attending the first grade in a suburban elementary school near Madison, Wisconsin. The chronological ages of the boys ranged from 77 months to 87 months with a mean of 80 months. The range in age of the girls extended from 70 months to 84 months with a mean of 79 months.

Measures of Muscle Size. Two soft tissue roentgenograms, one an anteroposterior view and one a lateral view of the right lower leg were obtained on each subject (see Figure I). For the anteroposterior view, the subject was placed in a supine position on the X-ray table. A cushion support was placed under the heel with the leg elevated slightly so that the calf at its widest part was approximately ¼ inch above the X-ray film. The knee was kept in an extended position and the toes were manually held, so that the foot was flexed to an angle of 90 degrees. The X-ray tube was centered over the broadest portion of the calf.

For the lateral view, the subject was rotated to the right side. Both the left hip and the knee were flexed to 90 degrees, with the left foot and knee resting on the table. The right leg was in extension with the foot elevated slightly, so that the calf was again approximately ¼-inch above the film. The foot was manually maintained in 90 degrees flexion. The X-ray was taken with the tube centered over the broadest portion of the calf.

All roentgenograms were obtained with a current strength of 100 milliamperes and 70 kilovolts. The exposure time was .4 of a second with all focal distances standardized at 36 inches.

As a check on distortion, a metal ruler with markings every half-inch was placed on the X-ray film adjacent to the part being X-rayed. Later measure-

ments of the shadow of the ruler on the film showed no measurable distortion within the area under consideration.

All measurements of the tissue components of the leg were made from tracings of the roentgenograms. These tracings were made on 14-in. x 17-in. pieces of cellulose acetate with matte finish (.005 in. thick). Each tracing was made directly from the X-ray film using a table top illuminator as the source of light.

FIGURE I. Photographic Reproduction of Anteroposterior and Lateral Roentgenogram of the Leg.

The method of obtaining the area and breadth measurements was patterned after the procedures developed by Stuart (10). On the tracing, the greatest breadth of the proximal head of the tibia was measured and the midpoint located. Similarly the midpoint on a line joining the widest part of the distal head of the tibia was marked. A line (a) was then drawn through these two midpoints (see Figure II). At the point where this line left the diaphysis of the tibia, transverse lines (b and c) were drawn perpendicular to line (a). The length of the diaphysis was considered to be the distance along line (a) bounded by the two transverse lines. At a point three-tenths of the length of the diaphysis, measured from the proximal transverse line, a third transverse line (d) was drawn at right angles to line (a). Stuart found that for children of this age a transverse line drawn at this point crossed the calf at its widest part with great regularity.

Muscle and bone areal measurements were taken between the proximal and distal parallel lines (b and c). The total muscle area in both views included the area bounded by the parallel lines and the borders of the muscle shadow. Since a considerable part of the muscle tissue was obscured by the bones, bony tissue was included in the areal measurements of muscle tissues. A disc planimeter was used for all areal measurements. The measurements were read to the nearest tenth of a square centimeter by means of an attached vernier scale.

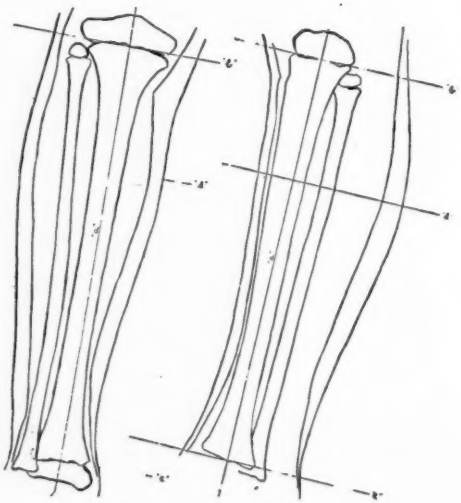

FIGURE II. Tracing of Roentgenogram Prepared for Measurement.

All breadth measurements were made on the line representing the broadest portion of the leg as described above. The total muscle breadths of the anteroposterior and lateral views also included the bony tissue. All breadth measurements were taken to the nearest millimeter.

Rather obvious limitations are imposed in the use of X-rays for measuring muscle size, in that no satisfactory method has been developed for obtaining accurate estimates of the cross section and volume of muscle from an X-ray film. In the present study, it was assumed that the structural arrangement of the fibers and the attachments of the muscles were similar for all children. No attempt was made to convert linear or areal measures into estimates of muscle cross-section or muscle volume.

Strength and Anthropometric Measures. The strength of the ankle extensors of the right leg was measured by the cable tension method as described by Clarke (2). The highest of three readings was used as the subject's ankle extensor strength.

The girth of the calf at its greatest circumference was taken with the subject standing. Maximum circumference was read with the tape at "light contact" tension.

Objectivity and Reliability of the Measures. Twenty roentgenograms were selected at random from the original group of 51 for re-measurement, The objectivity and reliability coefficients of the areal measurements are shown in Table 1. All breadth measurements from the roentgenograms gave objectivity and reliability coefficients above .97.

TABLE 1
Reliability and Objectivity Coefficients for Areal Measurements

Areal Measurements	Reliability	Objectivity
Total area (A-P view)	1.000	.975
Muscle area (A-P view)	.999	.990
Bone area (A-P view)	.998	.941
Total area (lateral view)	.999	.987
Muscle area (lateral view)	.996	.982

In determining the reliability of the strength test, the best score of each child was correlated with the average of the other two. Reliabilities of .96 and .91 were obtained for the boys and girls respectively.

The girth measurements of the lower leg were taken on two successive days by two examiners. Objectivity coefficients on the first and second day were .98 and .96 respectively. Reliability coefficients were .93 and .98 for the two testers. The scores obtained by the latter examiner on the first day were used.

Findings

The value of roentgenograms in the measurement of muscle and bone size is limited by the fact that only linear and areal measurements can be taken from the film and hence only estimates can be made in respect to tissue cross-section and tissue volume. Previous investigators have depended primarily upon a single roentgenographic view for obtaining measurements of the tissue components of the calf. In the present study, both anteroposterior and lateral roentgenograms of the calf were obtained on each subject, thus permitting both depth and breadth measurements to be made. The extent to which the measures taken at right angles to each other correlated with calf girth and with each other is shown in Table 2. It will be noted that the two measures of total area taken at right angles to each other were highly correlated. Likewise, the total breadth measures showed substantial correlations with calf girth, thus giving evidence that these measures agreed closely in differentiating children of varying calf size. As would be expected, lower coefficients were found between the muscle breadth measures and calf girth because of the variance in subcutaneous fat among children of the same external dimensions.

TABLE 2
Coefficients of Correlation between Total Areal Measures and Between Breadth Measures and Calf Girth.

Measures Correlated	Boys	Girls
Total area (A-P view)—total area (lateral view)	.98	.94
Total breadth (A-P view)—calf girth	.97	.95
Total breadth (lateral view)—calf girth	.98	.91
Muscle breadth (A-P view)—calf girth	.92	.85
Muscle breadth (lateral view)—calf girth	.91	.74

The degree to which the different areal and breadth measures correlated is shown in Table 3. The high coefficients, particularly for the boys, indicated that the various measures of tissue size including those taken at different angles were closely related. All the coefficients for the boys were higher than those obtained on equivalent measures for girls, due in part to the greater homogeneity of the measures obtained on the girls. The coefficients which were in closest agreement between the sexes were those which involved measures of muscle area and total area. For the girls, higher correlations were obtained between measures of muscle area and muscle breadth taken from the lateral view than for equivalent measures obtained from the anteroposterior view. On the other hand, the opposite was characteristic of the coefficients obtained for the boys in which the higher correlations occurred between the measures of muscle area and muscle breadth in the anteroposterior view.

TABLE 3
Coefficients of Correlation Among the Measures of Muscle and Bone Size

Measures Correlated	Boys	Girls
Muscle area (A-P view)—muscle area (lateral view)	.98	.89
Total area (A-P view)—muscle area (A-P view)	.97	.88
Total area (lateral view)—muscle area (lateral view)	.98	.90
Muscle area (A-P view)—muscle breadth (A-P view)	.90	.70
Muscle breadth (A-P view)—muscle breadth (lateral view)	.92	.73
Muscle area (lateral view)—muscle breadth (lateral view)	.86	.83
Muscle area (A-P view)—bone area (A-P view)	.96	.77

Muscle Size and Muscular Strength. Correlation coefficients between ankle extensor strength and the measures of muscle size and calf girth are given in Table 4. For the boys the correlations ranged from .58 to .63, whereas all of the coefficients for the girls were .52 or less. Although the lower correlations for the girls can be partly attributed to the relatively greater homogeneity of the girls' scores, it is not likely that this would account for the substantially lower coefficients involving muscle breadth (A-P view) and calf girth. The low correlation between calf girth and strength for the girls can be attributed to the relatively high and variable amounts of subcutaneous fat in girls. It is interesting to note that calf girth gave almost as high a correlation with the strength scores of the boys as was obtained with any of

the measures of muscle size. The calf in boys tends to be more predominately muscle and bone tissue than in girls and therefore higher coefficients with strength would be expected. For the girls, measures of muscle size obtained in the lateral view gave consistently higher correlations with strength than did the same measures taken in the anteroposterior view, while with the boys the opposite occurred.

While positive correlations were found between strength and radiographic measures of muscle size, it was apparent that factors other than muscle size as determined in this study were operating in determining the force the muscle developed. The fact that the correlations between the measures of muscle size and strength were not high would indicate that qualitative differences in muscle tissue contributed in part to the low correlations. Unfortunately, accurate estimates of qualitative differences in muscle tissue could not be made from observations of the roentgenograms. While the over-all bodily responses of the children indicated that motivation was high for the strength test, motivational differences particularly in the case of the girls might also have affected the correlations.

TABLE 4

Coefficients of Correlation between Measures of Muscle Size and Strength of the Ankle Extensors

Measures of Muscle Size	Boys	Girls
Muscle area (A-P view)	.63	.46
Muscle breadth (A-P view)	.63	.22
Muscle area (lateral view)	.60	.52
Muscle breadth (lateral view)	.58	.44
Calf girth	.60	.31

As an additional means of examining strength and muscle size relationships the muscle areas (A-P view) of the boys and girls whose strength scores fell in the upper and lower quarters of their respective distributions were plotted (see Figure III). It will be noted that seven of the eight strongest boys showed muscle areas one-half sigma or more above the group mean and seven of the eight weakest boys were one-half sigma or more below the group mean in muscle area. In the case of the girls, this method of dichotomizing the group did not differentiate so clearly between the strong and the weak.

In respect to individual cases, the strongest boy was the largest in all measures of muscle size. On the other hand, the strongest girl was slightly below the average for her sex on all measures of muscle size. The girl with the largest muscle measurements ranked fourth within her sex in strength. The weakest boy, although not at the bottom of the distribution in the measures of muscle size, ranked well below the average.

Sex Differences in Muscle Size and Muscular Strength. Comparative data for boys and girls on ankle extensor strength and the physical growth

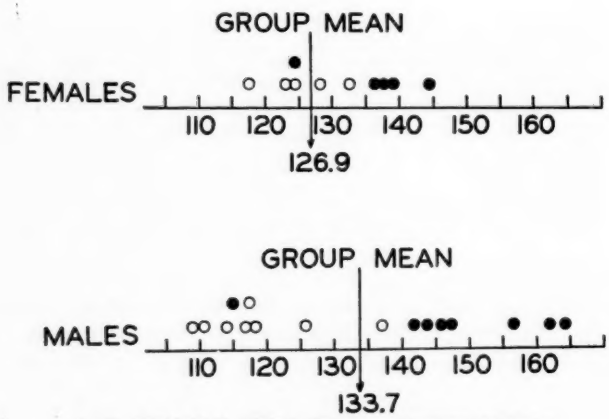

FIGURE III. Leg Muscle Areas of Boys and Girls in the Upper (*black dots*) and Lower (*white dots*) Quarters of their Respective Strength Score Distributions.

measures are given in Table 5. In strength of the ankle extensors, the boys were on the average approximately ten pounds stronger than the girls. Application of the t-test showed that the difference in the means was significant at the 2-per-cent level of confidence. On all measures of muscle and bone size the boys had higher mean values than the girls, although in height, weight and calf girth the two sexes were approximately equal. The superiority in the size of bone and muscle tissue exhibited by the boys in this study is in agreement with the findings reported by Stuart (11). The greater ankle extensor strength of the boys would therefore appear to be a function of the greater muscle mass available to the boys.

TABLE 5
Means and Standard Deviations of the Growth Measures

Growth Measures	Boys		Girls	
	Mean	S.D.	Mean	S.D.
Strength (lb.)	86.74	15.43	76.86	12.24
Muscle area,* A-P view (sq. cm.)	133.72	17.02	126.94	8.29
Total area,* A-P view (sq. cm.)	162.41	23.33	160.44	14.29
Total area,* lateral view (sq. cm.)	174.06	24.97	169.61	14.26
Muscle area,* lateral view (sq. cm.)	148.32	20.10	140.85	9.77
Bone area, A-P view (sq. cm.)	69.61	10.13	65.45	5.53
Muscle breadth,* A-P view (cm.)	7.01	.56	6.69	.41
Muscle breadth,* lateral view (cm.)	7.31	.73	6.96	.36
Girth (cm.)	25.14	2.15	24.87	1.53
Chronological age (months)	80.00	3.02	78.95	4.03
Height (cm.)	121.58	5.83	121.37	3.97
Weight (lb.)	52.65	8.23	50.83	5.60

*Includes bone tissue.

It is evident from a cursory inspection of Table 5 that the superiority of the boys in ankle extensor strength was out of proportion to their superiority in any of the structural measures. This is illustrated in Figure IV, which shows the per cent by which the boys exceeded the girls in ankle extensor strength and in the measures of muscle and bone size, calf girth, and body weight. The boys were approximately 13 per cent stronger than the girls, although they were only 5 per cent larger in the measures of muscle size, 3 per cent heavier and only 1 per cent larger in calf girth. The smaller differences between the sexes in body weight and calf girth reflected the relatively greater amount of fatty tissue and the proportionately smaller amounts of bone and muscle tissue on the part of the girls.

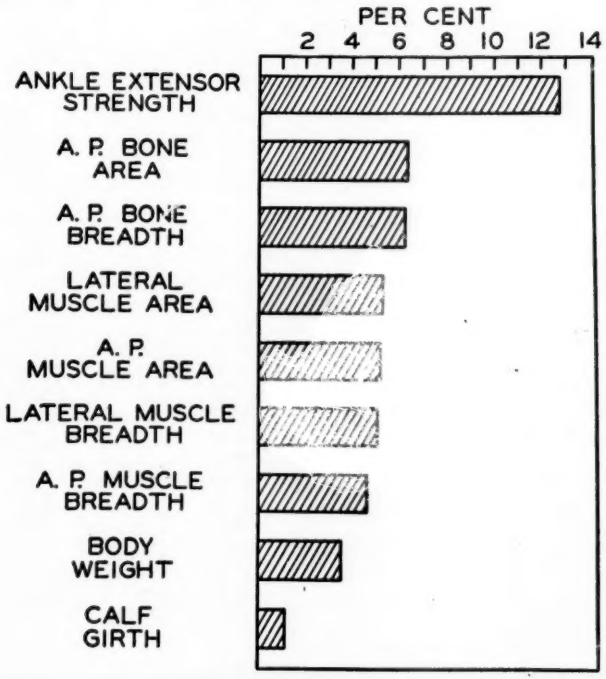

FIGURE IV. Percentage Superiority of Boys in Ankle Extensor Strength and in Measures of Muscle and Bone Size, Body Weight and Calf Girth.

The marked superiority of the boys in strength as compared to lesser sex differences in muscle size, provided some evidence that the boys were perhaps more effective in developing muscular force per unit of muscle size than the girls. In order to test this hypothesis under conditions in which muscle size might be more effectively controlled, 13 boys and 13 girls were matched as

closely as possible on measures of muscle size. The number of cases was limited because only 13 pairs could be satisfactorily matched on the four measures of muscle size. This eliminated six girls and 20 boys from the original group. Due to the fact that the girls on the average possessed smaller muscles than the boys, the equating procedure eliminated the larger and stronger boys and those with the larger muscle measurements. The effectiveness of the matching procedure is shown by the almost identical means and standard deviations of the four measures of muscle size (see Table 6). It will be noted that with the sexes thus equated the boys showed a mean difference in strength approximately six pounds higher than the girls. On the other variables the means and standard deviations of the two sexes were quite close with the exception of measures of bone size where the boys again proved to be superior. Although the mean difference in strength was not significant ($P = .30$), this difference was perhaps a conservative one since the measures of muscle size included bone tissue, which in the case of the boys was substantially larger than that for the girls. Therefore, the six pounds superiority in strength achieved by the boys was attained with less muscle tissue than was available to the girls.

TABLE 6

Differences in Ankle Exterior Strength of Seven-Year-Old Boys and Girls Equated on the Basis of Measures of Muscle Size

Growth Measures	Boys		Girls	
	Mean	S.D.	Mean	S.D.
Ankle extensor strength (lb.)	83.41	15.64	77.48	11.37
Muscle area,* A-P view (sq. cm.)	128.91	9.92	128.50	9.50
Muscle area,* lateral view (sq. cm.)	142.72	11.05	142.86	11.00
Muscle breadth,* A-P view (cm.)	6.84	.39	6.76	.39
Muscle breadth,* lateral view (cm.)	7.09	.41	7.05	.39
Calf birth (cm.)	24.65	1.51	24.95	1.73
Bone area, A-P view (sq. cm.)	68.12	6.22	65.95	6.01
Bone breadth, A-P view (cm.)	2.57	.16	2.48	.20
Chronological age (months)	80.46	2.55	79.46	4.50
Height (cm.)	116.43	3.78	118.15	4.43
Weight (lb.)	47.67	4.63	47.79	5.58

*Includes bone tissue.

With the small sample of seven-year-old boys and girls equated on the basis of measures of muscle size, the girls on the average possessed 92.5 per cent of the strength of the boys. This difference is small in comparison to reports on sex differences in strength of adults. For example, Morris (7) found that with equal muscle cross-section and equal leverage the muscular strength of women was only 78 per cent of the strength of men. The difference reported here is also less than that found by Brady (1) in a study of children in the age range 11 to 14 years in which girls showed 82 per cent of the strength of boys.

While the sex differences in strength of the boys and girls included in this study were not great, the question might be raised relative to possible qualitative differences in the muscle tissues of boys and girls. It is recognized that muscles of the same cross-sectional area differ in strength partly because of fatty tissue differences in the muscles (6). Studies have also shown that when boys and girls are paired on the basis of muscle size, boys show on the average the higher rate of basal oxygen consumption indicating a higher concentration of active tissue (4). It would, therefore, seem that the tendency shown by the boys to be slightly stronger per unit of muscle area than girls may be due to qualitative differences in the muscle tissue of the sexes. Such differences at this age level are more likely the result of differences in physical activity than of constitutional sex differences.

Summary and Conclusions

The relationship between roentgenographic measures of muscle size of the leg and ankle extensor strength of 51 seven-year-old children was investigated. Sex differences in strength and leg muscle size were also examined. Muscle size was obtained by breadth and areal measurements of soft tissue roentgenograms of the leg. Both anteroposterior and lateral views were taken on all subjects. Ankle extensor strength was determined by the cable tension method.

The correlations between ankle extensor strength and the measures of leg muscle size ranged from .58 to .63 for the boys. Substantially lower coefficients ranging from .22 to .52 were obtained with the girls.

The data showed that the boys were substantially stronger than the girls in ankle extensor strength ($P = .02$) and possessed on the average the greater areas and breadths of muscle tissue. The boys also exhibited on the average greater strength than the girls in proportion to the amount of measured muscle tissue. However, with pairs matched on the basis of the measures of muscle size the superiority of the boys in ankle extensor strength was significant at only the 30-per-cent level of confidence. While the evidence suggests that qualitative sex differences in muscle tissue may exist at this age level and that boys have at their command greater muscular power per unit of muscle mass than girls, further investigation is needed before definite conclusions can be drawn.

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Effect of Position of Forearm on Strength of Elbow Flexion

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Abstract

Twenty-four adult males were tested by means of a strain gauge dynamometer to determine the differences in the amount of elbow flexor tension which could be exerted when the forearm was in the supine position, the midposition, and the prone position. It was found that the greatest tension could be exerted in the midposition and the least in the pronated position.

SUBJECTS PARTICIPATING in experimental studies involving progressive resistance exercises frequently express surprise at the fact that much less weight can be handled in elbow flexion movements with the forearm pronated (reverse curls) than with the forearm supinated (curls). Although it might be assumed that this would be a matter of common observation, such does not appear to be the case. This phenomenon has been a matter of interest to kinesiologists (7), whose findings have shown considerable disagreement. This may, in part, be due to the fact that there has been some variation in the positions in which the subjects were placed during the measurements. It is also of importance to engineers and others concerned with the most efficient design and positioning of the intricate controls necessary to manipulate much of our modern apparatus.

Previous studies have been made with the subjects either supine or seated. Neither of these is the position normally assumed during exercise although much modern machinery is operated from a seated position. It was the purpose of this study to determine the effect of the position of the forearm on the strength of the elbow flexors while the subject was in the erect position, as is normally assumed during progressive resistance exercise, manual labor or the operation of machinery control panels.

Review of the Literature

Beevor (1) stated that when the forearm was fully pronated, the strength of the elbow flexors was 40 pounds; in the supinated and midposition it was 42 pounds. No information was given as to the method of testing or the subjects used.

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Wright (8) reported that she had experimented with spring balances to determine the position in which the elbow flexors were strongest and that the differences, if any, were not greater than the margin of error.

Downer (4) tested the flexion strength of 30 adult women with a Beasley myodynometer while the subjects were supine on a plinth. Results showed the greatest flexion strength to be with the forearm in the midposition. Supination was next, with an average of 3.6 pounds less than the midposition, and forearm pronation was found to be the weakest position.

Elkins, Leden, and Wakim (5) measured the flexion strength of nine women and nine men while the subjects were supine on a plinth. They found that the average difference in the three positions did not exceed 2 pounds for the women and 7 pounds for the men, but concluded that "evidently the midposition is slightly more efficient than supination or pronation."

Wells (7) conducted an experiment with ten college women, each of whom was seated in a chair with her right elbow supported on the arm rest. The elbow was flexed against the resistance of a grip dynamometer mounted on a wall. She reported the following mean scores:

Midposition	36.4 pounds
Supination	39.5 pounds
Pronation	31.6 pounds

Provins and Salter (6) worked with eight male and four female subjects. They were seated and attempted flexion against a handle attached to a strain gauge dynamometer. The mean maximum torques were as follows:

Pronated	3.89 kg.
Midposition	4.88 kg.
Supinated	4.65 kg.

They explained that the difference in strength of arm flexion at different forearm positions must have been due to some change in the efficiency or number of muscles involved, which were principally the brachialis, biceps, brachioradialis, and pronator teres. Of these, the brachialis was unaffected by the forearm position. The pronator teres and the brachioradialis had their greatest mechanical advantage at the midposition. The changes in the biceps and brachioradialis were believed to largely cancel themselves out, but pronation placed the pronator teres in a position in which the muscle was at its shortest length and its mechanical advantage relatively poor. On the basis of this analysis, Provins and Salter suggested that the reduction in the strength of elbow flexion shown when the hand was pronated was probably due to changes in the length and mechanical advantage of the pronator teres.

Procedure

The subjects for the present investigation were a group of 24 adult male students from the junior class at the College of Osteopathic Physicians and Surgeons. They ranged in age from 23 to 25 years; in height from 63.5 to 74.75 inches; in weight from 139.5 to 226 pounds.

Strain gauge dynamometer measurements of strength were obtained by use of a Baldwin SR-4 Load Cell which was firmly attached to the floor. This provided a means of translating changes in force or weight into changes in voltage. These voltage changes were amplified electronically and recorded by an ink-writing dynograph. Measurement of the amplitude of the dynograph pen excursions produced by weights hung from the load cell made it possible to calibrate the tension against the cell. Subjects exerted tension against the cell by means of a flexible airplane cable which led from the cell over a ball-bearing pulley attached to the floor and then upward to a handle. At the end of the cable was a short length of chain. By inserting the snap-hook on the cable at different links in the chain, provision could be made to adjust the apparatus to subjects of different heights. While the cable and pulley rig inevitably introduced a certain amount of friction into the system, it was believed to be negligible, and, in any event, was identical for all subjects and all positions of the elbow.

Elbow flexor strength was measured by having the subject face the pulley system, holding a stirrup handle with his palm up, his hand in line with his forearm, and his upper arm perpendicular to the floor. The elbow was held close to the body but not braced against it. By use of a goniometer, the subject's forearm was placed in an extended position 100 degrees from his humerus. The subject was moved until the cable led vertically upward from the floor pulley. The degree of elbow extension was again checked with the goniometer and readjustment made as necessary. The position of the subject is depicted in Figure I. The subject then voluntarily contracted his elbow flexors as strongly as possible. No jerking, leaning sideward or backward, shifting of weight, movement of the upper arm, or other accessory motion was permitted. Since the sensitive element of the load cell is virtually immobile and the cable is inelastic, this was actually an isometric strain.

After one minute of rest, the subject's forearm was pronated and the above procedure was repeated. It is recognized that fatigue may have possibly entered into the second and third tests. However, the one-minute rest period between tests was adopted in order to make the measurements more comparable with those of Wells' study (7).

A handle shaped like the letter *T* was then substituted for the stirrup handle. The subject's hand was placed in the midposition, the cross bar of the *T* resting across the outside of the first finger and the fold of flesh between the thumb and the first finger. The chain was again adjusted so that the subject's forearm was 100° from the humerus. On completion of a one-minute rest period, the subject again flexed his elbow as strongly as possible.

Results

Statistical data for these subjects in the three test positions are presented in Table 1. When the differences between any two of these three positions were evaluated by the *t* technique, they were found to be significant at the .001 per cent level of confidence. The results confirm some of the previous studies

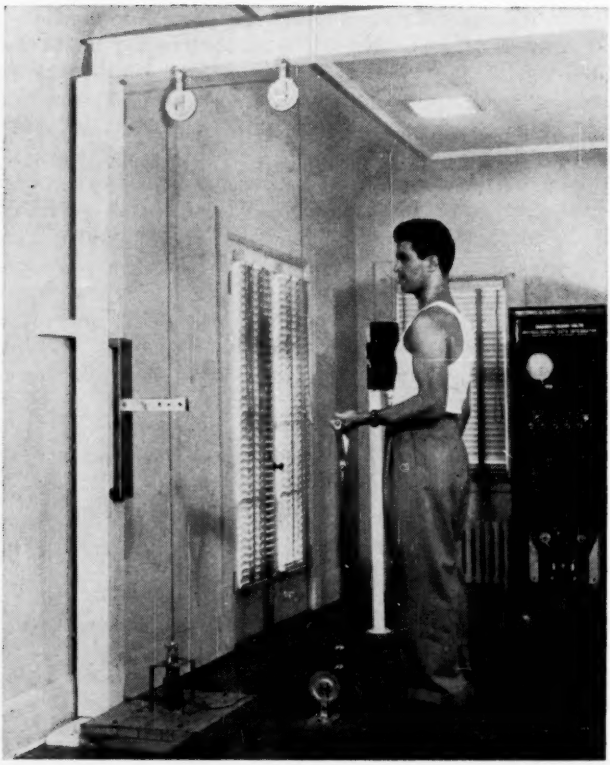

FIGURE I. Testing Subject for Arm Flexor Strength. Subject is grasping a stirrup handle which is connected through a series of pulleys to a strain gauge dynamometer. A change in tension or compression of the cell produces a change in output voltage of the strain gauge. The output from the strain gauge is amplified and recorded by an ink writing dynograph.

TABLE 1
Mean Strength of Elbow Flexion in Three Positions

Position	Mean (*Pounds*)	Standard Deviation (*Pounds*)
Supination	43.2	8.4
Midposition	47.8	8.9
Pronation	27.5	4.4

in which the midposition of forearm rotation was observed to be the strongest position for elbow flexion. The values for pronation strength in this study are relatively lower than those reported by previous investigators. However, the figures obtained in this study draw empiric support from texts on weight

training by Calvert (3), Berry (2), and others, who advise their readers that in the reverse curl exercise they will be able to employ approximately two-thirds of the weight they use in the curl. The mean curl weight in the present study was 43.2 pounds, and two-thirds of this figure is 28.8 pounds, which compares very closely with the mean of 27.5 pounds in the reverse curl position, as measured by the strain gauge. No information seems to be available in the literature on the correlation existing between strain gauge recordings and the amount of weight which can actually be curled in a normal exercise movement.

Conclusion

On the basis of this study, the following conclusion may be drawn: In the erect position subjects showed the greatest strength of elbow flexion, as measured by a strain gauge dynamometer, with the forearm in the midposition, the least in the pronated position, and intermediate in the supinated position.

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(Submitted 8/3/55)

Comparative Study of Certain Behavior Characteristics of Participant and Non-Participant Boys in Little League Baseball

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Abstract

This study dealt with boys ages 10 to 12. Half played Little League Baseball in 1954. The others, equated by age and grade, did not. Three measurement instruments were administered prior and subsequent to the season. *T* ratios were computed for differences between groups and between measurement periods. There was little difference in the number of problems expressed by the groups. The participants scored slightly higher each time on personality traits. Likewise, they received significantly higher social acceptance ratings from their peers each time. Changes during the study were inconclusive as to any effects of participation.

THE PROGRAM of Little League Baseball is one of relatively recent origin and one whose influence has become nationally prominent only within the past decade. Little League Baseball is baseball which has been modified for boys between the ages of 8 and 12. It was organized by Carl E. Stotz in 1939 in Williamsport, Pennsylvania. Its growth has been great, and in 1955 there were approximately 4,000 Little Leagues in the United States and in ten foreign countries.

Despite, or perhaps because of, its rapid growth and development, Little League Baseball has in recent years become the focal point of considerable controversy. Numerous claims and counter-claims have been aired as to the desirability of competition of this sort among boys 8 to 12.

It was the purpose of this study (1) to evaluate as objectively as possible some of the behavior characteristics of boys who participated in Little League Baseball and of boys who did not participate; (2) to make comparisons between these two groups in terms of these characteristics both prior and subsequent to the Little League season; and (3) to compare the changes experienced by each group during this period.

The following are the hypotheses examined by means of this study.

1. Participants in the Little League program would have fewer problems concerning health, self, home, school, and relationships with other people than would others of their age, grade, and environment who did not participate in the Little League program.

2. The participants in the Little League program would score higher on desirable personality traits of co-operation, social consciousness, emotional

adjustment, leadership, and responsibility, as measured by a reliable personality rating scale, than would their peers who did not participate.

3. Within their own groups, as represented by school classes, boys who took part in Little League Baseball would be accepted to a greater extent by the group than would non-participants. Additionally, the ratings which the participants gave to the members of the school classes would be higher and would reveal greater acceptance of the other members than would the ratings given by the non-participants.

4. All of the above differences between the participant and non-participant boys would exist prior to the start of Little League play. However, at the completion of the season, the differences between groups would be greater than they were initially.

Procedure

In order to measure the effects in terms of behavior characteristics upon participants in Little League play, a three-pronged approach was followed. In one case, the individual took a look at himself. Secondly, the teacher made ratings of the boys. Finally, the various children within a class rated one another.

Source of Data. For the purpose of the study, subjects were drawn from five Little Leagues located in and around the area of Atlanta, Georgia. These leagues were selected because of their proximity and because of the indication that co-operation on the study would be granted by representatives of the leagues. It was felt that the leagues selected were representative of the area in which the study was conducted.

At the time the study was initiated, it was desired to include as many of the boys who participated in Little League Baseball in these leagues in 1954 as was possible. This number was restricted by failure of some schools to participate in the study, by absence from school of boys on days when instruments were administered, and by changes of residence between spring and fall. At the completion of the study, the following number of Little Leaguers and a corresponding number of non-participants were included:

Glenwood Hills American League	41
Glenwood Hills National League	42
Smyrna Little League	23
Buckhead American League	5
Buckhead National League	3
	114

Evaluative Instruments Employed. In order to assay behavior characteristics from several angles, three different courses were followed. In one instance, the individual boys made self-appraisals by means of the Science Research Associates Junior Inventory,[1] a needs and problems inventory for

[1]Examiner Manual for the SRA Junior Inventory, Form A, Science Research Associates, Inc., Chicago, Ill., 1951.

elementary school children in grades 4 through 8. The second source of evaluation was the classroom teacher. For this evaluation, the Winnetka Scale for Rating School Behavior and Attitudes[2] provided the means for obtaining this information. Lastly, it was considered desirable for the subjects to be rated by their peers, in this case the boys and girls within the same class in school. The Ohio Social Acceptance Scale for the Intermediate Grades[3] was administered to all of the above-mentioned children as a check on social acceptance of both the participant and non-participant boys.

Administration of Measurement Instruments. As previously stated, five Little Leagues were selected prior to the start of the 1954 Little League season. After the selection of leagues, it was necessary to determine which elementary schools were attended by the boys who would be playing in the program, to contact these schools, and to enlist their support in the study. In the schools which provided such co-operation, all children in grades 4 to 6 were included. It was requested that all the boys complete the SRA Junior Inventory; that the teachers fill out the Winnetka Scale for all the boys; and that all the boys and girls complete the Ohio Social Acceptance Scale for the various members of their class. All the instruments which were completed through the help of the schools were then returned for scoring and recording.

At the termination of 1954 Little League play, the names of the boys who participated in the leagues were obtained through the co-operation of the officials of the various leagues. All of the scores obtained by these boys in the spring of 1954 were recorded for each league. After the start of school in the fall, the names of the children in grades 5 to 7 for the schools which took part in the study in the spring were procured. From this information, an equivalent group of non-participants was formed. The procedure in determining the composition of the non-participant group was as follows. The names of all non-participant boys who were in the same class with a participant in the spring and again in the fall and who were within six months of the same age as the participant were placed together, with pure chance determining which one represented the equivalent non-participant. As with the participants, all of the scores obtained by the non-participant boys in the spring were recorded for each league.

In the retest period in the fall, the SRA Junior Inventory was administered to just these two groups of boys rather than to all of the boys in these classes. Similarly, the Winnetka Rating Scale was executed by the teachers for only those boys included in the two groups. The Ohio Social Acceptance Scale was filled out by all boys and girls in the classes involved.

After scoring each of the three instruments, the scores on each were tabulated for each of the boys included in the study, so that the various com-

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[2]Dorothy Van Alstyne, "A New Scale for Rating School Behavior and Attitudes in the Elementary School." *Journal of Educational Psychology*, **27**:677-693 (Sept. 1936).

[3]William J. Goode and Paul K. Hatt, *Methods in Social Research*. New York: McGraw-Hill Book Co., Inc., 1952, pp. 258-9.

parisons between groups and between testing periods for the same individuals might be made. Only where scores were available from both testing periods for both the participant and his equivalent nonparticipant were the scores included in the tabulation.

Results of Study

In the tables which follow, the data are presented for each of the evaluative instruments which were used. One table presents the data as they reveal comparisons between participants and non-participants following each testing period. Thus, M_P indicates the participant group mean and M_{NP} designates the mean for the non-participants. D represents the difference between group means. The column *Favor of* shows which group had the lower mean on the SRA Junior Inventory and the higher one on the other two instruments. SE_{diff} gives the standard error of the difference between means and t stands for the critical ratio.

TABLE 1
SRA Junior Inventory
Difference Between Groups

Section	N	M_P	M_{NP}	D	Favor of	SEdiff	t
Initial Testing							
My Health	178	3.17	4.18	1.01	Part.	.53	1.86
Getting Along With Others	178	2.56	3.88	1.32	Part.	.58	2.29*
Me and My School	178	6.19	7.89	1.70	Part.	1.11	1.53
About Myself	178	5.45	6.75	1.30	Part.	.88	1.49
Me and My Home	178	3.44	4.39	.95	Part.	.74	1.28
Final Testing							
My Health	178	2.44	2.54	.10	Part.	.43	.23
Getting Along With Others	178	2.19	2.67	.48	Part.	.57	.84
Me and My School	178	4.32	4.30	.02	Non-Part.	.70	.02
About Myself	178	3.97	4.10	.13	Part.	.73	.18
Me and My Home	178	2.62	2.52	.10	Non-Part.	.56	.18

*Significant at the .05 level.

The second table gives the data as they reveal comparisons between testing periods for both the participant and non-participant groups. In this instance, M_1 is used to represent the mean on initial testing and M_2 designates the mean on final testing. D shows the difference between these two means and a negative figure indicates a smaller mean on final testing. SE_{diff} gives the standard error of the difference between means and t gives the critical ratio.

The initial hypothesis was that participants in the Little League program would indicate fewer problems concerning health, getting along with others, school, self, and home than would others of their age, grade, and environment who did not participate. The results of the initial administration of the SRA Junior Inventory reveal that this situation was true in each of the five areas, although, in terms of statistical significance, the differences between the two

groups were significant only for the section Getting Along With Others. The data procured from the final testing period, subsequent to the Little League season, reveal that the participant boys indicated fewer problems for My Health, Getting Along With Others, and About Myself, while the non-participant group designated fewer needs and problems in the areas entitled About Me and My School and About Me and My Home. In none of the five areas was the difference between groups on final testing of significance at the .05 level.

TABLE 2
SRA Junior Inventory
Difference Between Spring and Fall

Section	N	M1	M2	D	SEdiff	t
Participants						
My Health	89	3.17	2.44	— .73	.32	2.31[1]
Getting Along With Others	89	2.56	2.19	— .37	.40	.94
Me and My School	89	6.19	4.32	—1.87	.77	2.43[1]
About Myself	89	5.45	3.97	—1.48	.56	2.67[2]
Me and My Home	89	3.44	2.62	— .82	.42	1.96
Non-Participants						
My Health	89	4.18	2.54	—1.64	.38	4.31[2]
Getting Along With Others	89	3.88	2.67	—1.21	.44	2.71[2]
Me and My School	89	7.89	4.30	—3.59	.66	5.47[2]
About Myself	89	6.75	4.10	—2.65	.57	4.66[2]
Me and My Home	89	4.39	2.52	—1.87	.48	3.90[2]

[1]Significant at the .05 level.
[2]Significant at the .01 level.

In the final hypothesis, it was proposed that these differences between participant and non-participant boys would exist prior to the start of Little League play, but that, at the completion of the season, the difference between groups would be greater than at the start. To investigate this hypothesis, it was necessary to ascertain what changes took place within each group during the time of the study. Subsequent to that, a comparison of the change experienced by one group with that made by the other group would indicate what differences might be attributed to the participation or absence of participation in Little League Baseball.

On the SRA Junior Inventory, both the participant and the non-participant groups improved, since the mean for each on all five sections was less on the final test period. The participant mean decreased significantly on My Health (.05), About Me and My School (.05), and About Myself (.01). For the non-participants, the decline was significant at the .01 level on all five sections.

Comparing the differences revealed by each group, it is noted that the non-participant group had a greater decrease in all five sections than that of the participants. This greater change by the non-participants was significant at the .01 level on Sections 2 and 5, Getting Along With Others and About Me and My Home. On Sections 1 and 3, My Health and About Me and My School, the difference was significant at the .05 level.

Thus, it is evident that the stated hypotheses concerning needs and problems were rejected, except Getting Along With Others, on initial testing.

The second hypothesis proposed that the participant boys would score higher on desirable personality traits of co-operation, social consciousness, emotional adjustment, leadership, and responsibility, as measured by a reliable personality rating scale, than would their peers who did not participate. It may be readily noted from the ratings assigned by the teachers in the spring and fall of 1954 that the participants rated higher in every trait on both testing periods than did the non-participants. In terms of statistical significance, though, the only trait in which there was a significant difference on initial rating was that of Leadership in which significance was reached at the .05 level. The same situation prevailed on the final ratings except that the difference for Leadership at that time was significant beyond the .01 level.

TABLE 3
Winnetka Rating Scale
Difference Between Groups

Trait	N	M_P	M_{NP}	D	Favor of	SEdiff	*t*
Initial Testing							
Co-operation	166	18.33	17.03	1.30	Part.	1.45	.90
Social Consciousness	166	17.78	16.45	1.33	Part.	1.43	.93
Emotional Adjustment	166	19.37	17.22	2.15	Part.	1.39	1.55
Leadership	166	19.18	16.43	2.75	Part.	1.30	2.11[1]
Responsibility	164	18.52	17.11	1.41	Part.	1.47	.96
Final Testing							
Co-operation	166	21.20	19.68	1.52	Part.	1.27	1.19
Social Consciousness	166	19.15	17.90	1.25	Part.	1.38	.91
Emotional Adjustment	166	20.19	18.45	1.74	Part.	1.21	1.43
Leadership	166	21.61	16.26	5.35	Part.	1.15	4.66[2]
Responsibility	164	19.74	18.40	1.34	Part.	1.35	.99

[1]Significant at the .05 level.
[2]Significant at the .01 level.

The major hypothesis of the study was that greater improvement in the behavior characteristics under examination would be made by the participants during the course of the study than by the non-participants. In the main, this hypothesis cannot be supported by the data obtained through the Winnetka Scale except in the area of Leadership. For this one trait, the participant group mean was larger initially, was higher on final rating, and made an advance during the study which was significantly higher than the change in the non-participant group with the difference between these group changes significant beyond the .01 level of confidence. Non-significantly larger percentages of increase in group means were recorded for the non-participant group for Social Consciousness, Emotional Adjustment, and Responsibility. For Co-operation, the two groups had identical increases in terms of percentage gain from initial means, although the actual difference between group means was enlarged at final testing.

TABLE 4
Winnetaka Rating Scale
Difference Between Spring and Fall

Trait	N	M1	M2	D	SEdiff	t
Participants						
Co-operation	83	18.33	21.20	2.87	1.05	2.74[1]
Social Consciousness	83	17.78	19.15	1.37	1.14	1.21
Emotional Adjustment	83	19.37	20.19	.82	.97	.85
Leadership	83	19.18	21.61	2.43	1.03	2.36[2]
Responsibility	82	18.52	19.74	1.22	1.06	1.15
Non-Participants						
Co-operation	83	17.03	19.68	2.65	1.01	2.61[2]
Social Consciousness	83	16.45	17.90	1.45	1.10	1.32
Emotional Adjustment	83	17.22	18.45	1.23	1.08	1.14
Leadership	83	16.43	16.26	—.17	.98	.17
Responsibility	82	17.11	18.40	1.29	1.02	1.27

[1]Significant at the .01 level.
[2]Significant at the .05 level.

It was proposed that within their own groups, as represented by school classes, boys who took part in Little League Baseball would be accepted to a greater extent by the group than would non-participants. Additionally, it was postulated that the ratings which the participants gave to the members of their school classes would be higher and would, thus, reveal greater acceptance of the other members than would the ratings given by the non-participants. The first part of the hypothesis is given emphatic support by the data. These show that the participants received ratings from both boys and girls on each rating period which were statistically significantly greater at the .01 level than the same ratings received by the non-participants. In terms of "social acceptability," or willingness to accept others, there is little support from the data for the hypothesis that the participant group would rank higher here. On initial ratings, the participant mean was higher for ratings given to boys and

TABLE 5
Social Acceptance Scale
Difference Between Groups

Ratings	N	M_P	M_{NP}	D	Favor of	SEdiff	t
Initial Testing							
From Boys	180	9.51	7.79	1.72	Part.	.34	5.01*
From Girls	180	5.71	4.64	1.07	Part.	.33	3.21*
To Boys	134	8.56	8.35	.21	Part.	.38	.55
To Girls	128	5.22	5.84	.62	Non-Part.	.52	1.20
Final Testing							
From Boys	180	9.36	7.55	1.81	Part.	.30	6.11*
From Girls	180	6.26	4.86	1.40	Part.	.31	4.53*
To Boys	134	7.98	8.00	.02	Non-Part.	.36	.04
To Girls	128	5.43	4.96	.47	Part.	.41	1.15

*Significant at the .01 level.

the non-participant mean was higher for ratings given to girls. On final ratings, the positions were reversed. None of the differences were significant at either time on these two scores.

TABLE 6
Social Acceptance Scale
Difference Between Spring and Fall

Ratings	N	M1	M2	D	SEdiff	t
Participants						
From Boys	90	9.51	9.36	−.15	.20	.74
From Girls	90	5.71	6.26	.55	.19	2.88*
To Boys	67	8.56	7.98	−.57	.31	1.85
To Girls	64	5.22	5.43	.21	.35	.58
Non-Participants						
From Boys	90	7.79	7.55	−.24	.23	1.04
From Girls	90	4.64	4.86	.22	.21	1.05
To Boys	67	8.35	8.00	−.35	.32	1.09
To Girls	64	5.84	4.96	−.88	.46	1.91

*Significant at the .01 level.

It is necessary, also, to look at the data in terms of the final hypothesis which predicated that greater improvement would be made by the participant group in these areas of acceptance and acceptability than would be exhibited by the non-participants. It is noted that the differences between participants and non-participants increased in favor of the former on ratings received from boys, ratings received from girls, and ratings given to girls. The difference on ratings given to boys was in favor of the non-participants. Except for the score on ratings given to girls, no differences in group changes were significant. In that one case, the difference was significant at the .01 level. Thus, the hypothesis that the participants would make greater advances in terms of acceptance by boys and girls of their classes than would the non-participants must be discarded. Likewise, the hypothesis of greater increase in willingness to grant acceptance to boys in the class by the participants does not receive support from the data of the study. The data sustain the hypothesis of greater increase by the participants in willingness to grant acceptance to girls.

Conclusion

From the results of this study, it may be said that many of the statements both pro and con which have been credited to various persons about the changes in behavioral pattern resulting from the program of Little League Baseball have little substantiation in fact.

As the child views himself and his needs and problems, no significant difference is evident between participant and non-participant. Neither can it be concluded that the program of Little League Baseball has appreciably affected in a negative or positive manner the problems confronting the boys included within the study. To be sure, the non-participant group showed significantly

greater decreases in the number of felt needs and problems in all but one section. However, even following such change, the differences between groups were non-significant in each area, with the non-participant group mean lower in two and higher in the other three areas.

In terms of desirable personality traits, it is noted that the participant group does possess, at least as indicated in the ratings made by the teachers, a somewhat higher degree of these traits both prior and subsequent to participation in the program of Little League Baseball. It must be borne in mind, however, that these differences were not statistically significant at or beyond the .05 level, with the exception of Leadership. In the latter case, there may be some basis to the claim that participation in programs such as Little League Baseball makes valuable contributions toward the acquisition of this desirable attribute. This is supported by the fact that, although the participant group possessed a significant initial superiority, it still made an increase which, when compared with the change experienced by the non-participant group, exceeded the .01 level.

The data derived from the Ohio Social Acceptance Scale present rather conclusive evidence that in grades 4 to 7, at least, the boys who participate in athletic programs are accorded a higher level of social acceptance. It would appear from the results of this study to be a completely untenable criticism of the program that it breeds a class of egotists who cannot get along with their peers following their participation in this program. The evidence obtained shows that, even though the initial ratings granted the participants were superior to those for the non-participants, the participant group was still able to increase this difference following the season of participation.

The hypothesis that a comparable difference in "outgoingness" or willingness to grant acceptance to others at a high level would exist in favor of the participants is not supported by the data which indicate no significant difference between the two groups in their granting of acceptance to boys and girls.

As a final conclusion of this comparison of behavior characteristics of participant and non-participant boys in Little League Baseball, it would seem prudent to exercise caution in ascribing with any degree of certainty behavioral changes, whether desirable or undesirable, to Little League Baseball or to any comparable program for youth.

This study has revealed that there is little difference in the number of problems or needs affecting the participants and non-participants. The boys who take part in the Little League program come into it somewhat better endowed in terms of desirable personality traits and retain that position during and after participation with little change in the difference between the two groups. In the same fashion, the boys who take part in Little League Baseball start at a higher level of social acceptance and retain that advantage. In fact, they tend to widen the difference between themselves and the non-participants, although the added difference cannot be termed statistically significant at the usual acceptable levels.

(Submitted 1/26/56)

Performance of Selected Groups of Male College Students on the Reynolds' Balance Test

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Abstract

The Reynolds' Balance Test was administered to selected groups of varsity athletes, physical education majors, and liberal arts majors. Significant differences in mean balance scores were found between all groups. The performance of the groups was, in descending order: varsity athletes, physical education majors, and liberal arts majors. It was suggested that the Reynolds' Balance Test gives promise of being a valuable addition to physical education testing programs.

THE PURPOSE of this investigation was to obtain preliminary evidence on the extent to which a new balance test would discriminate among selected groups of male college students. The test, recently described by Reynolds (1), provides completely objective scores, requires little time to administer and offers a challenging balance task to the student.

Method

Apparatus. Figure I presents a photograph of the apparatus utilized by the subject. The complete apparatus is best described in terms of the following units: (a) teeter-board, (b) response display, (c) stimulus display, and (d) timing unit.

(a) The teeter-board consisted of a 40 in. x 7½ in. x 1½ in. balanced board which could be rotated about a metal axle.[1] The axle was supported by two metal uprights so that the board rested 13 inches about the apparatus base. Two 7½ in. x 1 in. x 1 in. wooden strips, located 7 inches in from each end of the board, served as foot rests. On the apparatus base, a wooden block was positioned beneath each side of the board. These blocks served as stops, and they permitted the foot rests at each end of the board to move downward for a distance of 4½ in.

To provide some resistance in the teeter-board system, a pneumatic stop was attached to each end of the board. The resistance in these stops was adjusted so that a 5-pound weight, placed against the outer edge of a foot rest, would cause the board to travel from a horizontal position down to the wooden stops in 2.5 sec.

[1]Although certain physical dimensions of the apparatus used in this investigation differed from those of the original model, the circuits were designed to perform as described by Reynolds (1).

A moving contact arm was suspended from the bottom of the board. During a complete excursion of the board, this contact arm moved across five fixed contacts. These contacts served as switches to activate the response display.

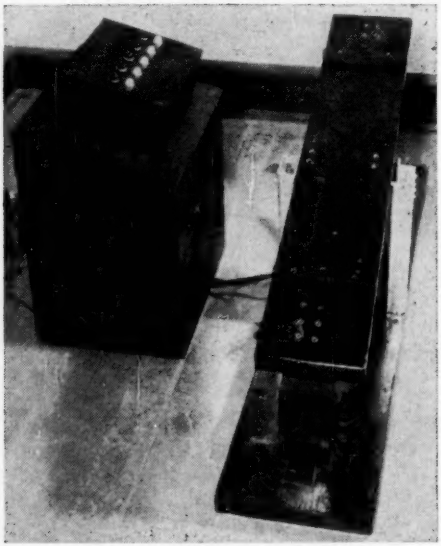

FIGURE I. Balance Apparatus.

(b) The response display consisted of a row of five white lamps located directly in front of the teeter-board. These lamps were mounted to the top of a 11 in. x 8½ in. x 4 in. box, and the box was attached to a 16 in. x 12 in. x 16 in. sloping panel cabinet. The circuits to these lamps were made and broken when movement of the teeter-board caused the contact arm to move across the fixed contacts. The arrangement was such that the lamps were activated in phase with movement of the board. With the board in a horizontal position, the center lamp was activated. When the right half of the board was depressed so that the foot rest was lowered 1½ in. from the horizontal position, the first lamp to the right of center was activated. Lowering the foot rest another 1½ in. activated the last lamp to the right of center. In a similar manner, lowering the left half of the board activated the lights to the left of center.

(c) The stimulus display consisted of five red lamps. These lamps were mounted directly above the response lamps so that the two displays formed five pairs of red and white lamps. The circuits to the red lamps were closed through a relay-driven stepper. During a complete cycle of the stepper, the red lamps were activated 25 times. The order in which the lamps were activated was randomized with the restrictions that no lamp succeeded itself and that each lamp be activated five times during a cycle of the stepper.

The stepper relay was operated by an electronic time-delay switch, which was controlled by the two display circuits. Whenever the circuits to a pair of red and white lamps were closed for an interval of .15 sec., the time-delay switch momentarily closed and energized the stepper relay. Advancement of the stepper opened the previously closed red lamp circuit and closed a different red lamp circuit. By sequentially closing the circuit of the white light directly below a closed red light circuit, the complete cycle of stimulus displays was obtained. With this system, operation of the apparatus was completely automatic, and each subject was presented the stimulus displays in the same order.

(d) The timing unit included two 0.01 sec. standard electric clocks. One clock recorded the time required by a subject to complete the sequence of 25 stimulus displays. The second clock recorded the interval between closing of paired lamp circuits and closing of the time-delay switch. This latter clock provided a constant check on the delay switch.

Subjects's task. With the subject standing on the teeter-board, his task was to activate the white response lamp directly under any activated red stimulus lamp. This was accomplished through movement of the teeter-board. When the paired lamps had been matched for an interval of .15 sec., another stimulus lamp was activated. The subject then moved over to the new position, and this procedure was repeated until a complete sequence of stimulus lamps had been matched.

Subjects and procedures. Sixty-six male undergraduate students at Indiana University served as subjects. The subjects were obtained on a volunteer basis and consisted of the following groups: (a) 22 varsity athletes, (b) 22 physical education majors who were not varsity athletes; and (c) 22 liberal arts majors who were not varsity athletes. The varsity athletes and the physical education majors were recruited from the experimenter's two undergraduate classes, and the liberal arts majors were recruited from a colleague's undergraduate psychology class. The different groups were selected on the hypothesis that they would probably differ in motor ability. Since balance is generally recognized as a component in motor performance, it was also felt that the groups might give differential responses on the balance test.

All subjects were tested individually. Standardized instructions and demonstrations were given at the start of each testing period. During this explanation and demonstration, it was emphasized that: (a) the feet were to be kept against the foot rests at all times, (b) the hands could be used in any manner desired with the exception that they could not be rested on the thighs; (c) the stimulus lamps would not change until they had been matched for a brief period of time; and (d) the stimulus lamps were to be matched as quickly as possible.

Each subject was given five practice trials on the last five positions of the stimulus cycle. Upon completion of these trials, the subject matched the entire sequence of stimulus presentations.

Scoring and analysis of data. The total time required to match a cycle of 25 stimulus presentations constituted the balance scores. With scores for several independent groups of subjects, a two-part analysis of variance was performed. Bartlett's test was used to evaluate the assumption of homogeneity of variance within groups. The *t*-test was used to evaluate the difference between means. In applying these individual tests, the standard errors of the differences were based upon the error variance from the over-all analysis of variance.

Before collection of the data, it was decided to require a significance level of 5 per cent for rejection of the null hypothesis. Having decided upon this class of results, no attempt was made to indicate the maximum level of significance for *F* and *t* values.

Results and Discussion

Since the time scores showed heterogeneity of variance, it did not seem desirable to attempt an analysis of variance and *t* tests with the original scores. However, a logarithmic transformation of the original scores corrected the heterogeneity of variance, and the analysis is presented in terms of the transformed scores. Table 1 summarizes the means and variances of the original and transformed data for each group of subjects.

TABLE 1

Means and Variances of Original and Transformed Scores of Balance Scores for Selected Groups of Subjects

Group	Original Data (*sec.*)		Transformed Data (*logs*)	
	Mean	Variance	Mean	Variance
Varsity Athletes	56.81	51.16	1.75083	.07122
Phys. Educ. Majors	66.82	194.08	1.81589	.17219
Liberal Arts Majors	75.97	129.97	1.87594	.09073

The variance analysis of the transformed balance measures is summarized in Table 2. As shown in Table 2, "Between groups" was found to be a significant source of variation. For 2 and 63 degrees of freedom, an *F* of approximately 3.15 is significant at the 5-per-cent level. The obtained *F* of 16.25 was interpreted as being indicative of significant differences in the balance performance of the several groups.

TABLE 2

Analysis of Variance of Transformed Scores for Balance Test

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	.17228	2	.08614	16.25*
Within groups	.33413	63	.00530	
Total	.50641	65		

*Significant beyond 5%.

Table 3 summarizes the comparisons between mean balance scores for the several groups. The results of this analysis revealed all comparisons to be significant beyond the 5-per-cent level. Since success on the balance test

was inversely related to the magnitude of time measures, it was concluded that varsity athletes were significantly better than physical education majors and liberal arts majors; and physical education majors were significantly better than liberal arts majors.

TABLE 3

Comparisons Between Means of Transformed Balance Scores

Group	Balance Score	Diff.	S.E of Diff.	t
Varsity Athletes	1.75083			
Phys. Educ. Majors	1.81589	.06506	.02195	2.96*
Varsity Athletes	1.75083			
Liberal Arts Majors	1.87594	.12511	.02195	5.70*
Phys. Educ. Majors	1.81589			
Liberal Arts Majors	1.87594	.06005	.02195	2.74*

*Significant beyond 5%.

It is, of course, recognized that the sampling method places definite restrictions upon the extent to which one can generalize the experimental findings. The source of subjects was limited to three university classes accessible to the investigator, and only volunteers from these classes could be tested. With these limitations in mind, it is recommended that group differences simply be considered as suggestive of real differences for the classes of subjects involved.

In regard to the major purpose of this investigation, the preliminary findings suggest that the Reynolds' Balance Test gives definite promise of being a valuable addition to physical education testing programs.

The balance apparatus developed by Reynolds is extremely flexible, and it may be modified in several ways. For example, the difficulty of the balance task may be varied by changing either the resistance in the system or the time required to match the lamps. With minor changes in the connections between teeter-board contacts and response lamps, the apparatus may be modified to present an interesting problem-solving task. In this latter type of task, the subject would be required to discover and learn the relationships between teeter-board movement and activation of the response lamps.

Conclusions

Preliminary evidence was collected on the extent to which the Reynolds' Balance Test would discriminate among selected groups of varsity athletes, physical education majors, and liberal arts majors. For the subjects tested in this investigation, it was concluded that:

1. Varsity athletes performed significantly better on the balance test than physical education majors and liberal arts majors.
2. Physical education majors performed significantly better on the balance test than liberal arts majors.
3. The Reynolds' Balance Test gives promise of being a valuable addition to physical education testing programs.

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Characteristic Likenesses and Differences Between Skilled and Non-Skilled Performance of Standing Broad Jump[1]

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Abstract

Cinematographical analysis was used to compare spatial and temporal relationships of ten skilled and ten non-skilled performances of the standing broad jump. Means of the extent and duration of major joint action for the two levels of skill were represented graphically. Characteristic likenesses appeared in the general patterns of movement of limbs and in proportion of time consumed by the phases of the movement. Characteristic differences were found in angles of take-off and of landing and in extent and duration of specific joint actions. Greater extent of movement occurred in the skilled performances. The latter characteristically used more time in hip flexion and less time in knee extension.

HUMAN MOVEMENT has been studied with several points of emphasis. While some investigators have been primarily concerned with neural activity, others have emphasized the character of movement as a manifestation of muscle action. Still others have sought the factors of which a skill is composed.

Purpose of the study

The purpose of this study was to ascertain characteristic likenesses and differences between skilled and non-skilled performance of a basic large-muscle motor activity.[2] Characteristic likenesses can be considered as basic to the movement while characteristic differences may disclose major difficulties to overcome in the development of skill. A comparison of the results of this study with those of similar studies of other basic skills might reveal common characteristics of skilled movement.

Review of Related Literature

Previous investigators have found a number of items important in movement. Some of these, such as the effect of the shifting of the center of gravity

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[1]This study was carried out in partial fulfillment of the requirements for the Doctor of Philosophy degree in the School of Education, University of Wisconsin, under the direction of Dr. Ruth B. Glassow and Dr. A. S. Barr.

[2]The standing broad jump was chosen since it has been considered a fundamental human activity. The inclusion of jumping in batteries of events designed for testing fundamentally different abilities has been advocated by McCloy (23, *p. 38*), Cureton (9, *p. 20*), Rogers (27, *p. 23*), and Brace (3, *p. 249*). Scott (28, *p. 165*) used combined scores on the standing broad jump, the run and the overhead throw as one of the four criteria to evaluate tests of skills in college women.

of the body and the control of equilibrium, were major concerns in early investigations as well as in more recent studies. In 1836 Wilhelm and Ernst Weber (4), in their analysis of walking, noted that as the length of the stride increased there was an accompanying sinking of the center of gravity. Marey's (21) measurement of the vertical oscillations of the body in running disclosed his interest in the movement of the center of gravity. More recent studies carried out by Fenn (11, 12) also point to the importance of this item in movement. When investigating the action of throwing and changes in body movement which accompany learning to throw, Brophy (5) found control of equilibrium important.

Body movement has been partially explained in terms of lever action. James Bell Pettigrew (26) was among the first to note the effects of physical forces on the action of body levers. Since the completion of his work, kinesiologists and students of body mechanics have analyzed the leverage of many movements. In a recent study of jumping by children, Wilson (33) analyzed major joint action and studied angles of take-off. Brophy (5) found that increase in throwing skill was accompanied by increased range of movement of levers of the arms, trunk, and legs.

Students of locomotion have been concerned with the effects of varying amounts of pressure against a supporting surface. Marey (21) contrived an experimental shoe and chronograph which recorded the duration of pressures of the foot upon the ground in walking and in running. He found that the duration of the phases of pressure affected the movement. Fenn (11, 12) also noted the influence which the forward and backward pressure of the foot had upon the movement in running.

Temporal organization of movement has been found important in different types of activity. Freeman (13) studied differences in handwriting at varying stages of its development by investigating changes in speed in the writing of different parts of letters and in the pressure used. He found that the handwriting of adults was an organized process and had a decided rhythm. Kreezer and Glanville's analysis of human gait (20) was based on the idea that all complex motor activity consists essentially of a temporal organization of the positions and movements at the joints involved. In studying throwing, Wild (32) constructed type patterns of movements showing the temporal relationships between selected phases of the throw. Clayton (6) sought the starting times of various joint actions in jumping by children six through twelve years of age. She found a tendency for thigh and trunk flexion to occur earlier in the jump as the performer advanced in age.

Acceleration and deceleration of the limbs and the relative velocity of the head and pelvis were two additional items which Fenn (11, 12) found important in his analysis of running. Hubbard (19) in studying walking and running found that tense movements were inefficient, while in ballistic movements, as the antagonists relaxed, momentum developed and the movement continued its course.

The literature revealed that the items which other investigators found to be important in movement include shifting of the center of gravity of the body, control of equilibrium, leverage employed, changes in angles at major joints, range of movement, amount and duration of pressure upon the ground, rhythm or temporal organization of different phases of the movement, acceleration and deceleration of body segments, and evidence of pendular motion of the limbs.

Procedure

After investigating methods of studying movement, it seemed that cinematographic analysis was most advantageous for the present study. Accordingly, it was decided to analyze side-view motion pictures of ten skilled and ten non-skilled performances of the standing broad jump. Before selecting the performances to be analyzed, it was necessary to establish a set of criteria which the judges[3] could use in rating skill. For this purpose a preliminary study was carried out.

Three groups in the Department of Physical Education for Women at the University of Wisconsin participated in the preliminary study. One group was made up of four faculty members of professional rank; another, of 12 instructors of sports and dance; and a third was composed of six graduate students. Each group designated a set of criteria for judging movement and used it to rate moving pictures or actual performances of students in a variety of sports and in dance. The criteria were then revised in the light of their adequacy when applied. From the three sets of criteria, it was found that the major items which the groups considered when rating skill included: choice of levers; nature and extent of movement of the levers; timing of lever action; shifting of the center of gravity; and duration of the different phases of movement in relation to each other and to the whole movement. Though expressed in somewhat different terms, these criteria were similar to items found important by previous investigators of movement. They were later used in selecting the performances analyzed in the present study.

The subjects[4] were chosen from two groups which were considered to be characterized by extremes of skill in movement. The skilled performers were advanced major students and physical education instructors, while the non-skilled were Freshman non-majors who ranked in the lowest sigma of the Freshman class in a composite test of five motor skills. Since the skilled performers were obtained from groups already selected as to skill, it was con-

[3]The judges, two members of the Women's Physical Education Department of the University of Wisconsin, were experienced in teaching fundamental motor skills as well as in analyzing and rating performances.

[4]No extremes of body type occurred in this study. However, the influence of body type on the performance of large muscle motor skills in women seems uncertain. According to Webster (31, *p. 239*), tall, slim girls and short, stocky ones seem to achieve equally good results in the standing broad jump. Beall (2, *p. 51*) found that certain specific body measurements were possessed by a majority of skilled performers in a given activity, but no type of body build could be identified for any of the four activities she investigated. McCloy (23, *p. 162*) classifies girls only by age and that only up to 13½ years.

sidered unnecessary to administer the motor skills test to them. Both groups were rated as to skill in broad jumping by the two judges who applied the criteria derived from the preliminary study. An additional criterion was applied to the ten performances which received the highest ratings for skill and also to the ten receiving the lowest ratings. Distances jumped by these subjects were compared with standards for college women found in the *Federal Security Agency Handbook of Fitness for Students of Colleges and Universities* (10). All skilled jumpers merited the highest score, while the records of all non-skilled performers fell in the lower half of the standard. The photographed performances of these subjects were also measured and were found to receive the same score on the standard as had been attained at the time the ratings were given.

In analyzing the standing broad jump from the standpoint of mechanics, the movement was found to consist of three phases: first, the application of force for the take-off; second, projection of the body upward and forward; and third, the descent occurring after gravity has overcome the vertical component of force and momentum continues. It was decided to study the movement of the center of gravity and the extent and temporal organization of lever action in each of the three phases, as well as in the whole movement.

The film was placed in the Recordak machine and, after locating the frame in which each of the three phases of the movement began, the major levers active were noted and the extent of their action in each phase measured. This involved measurement of the angles at the hips, knees, and ankles in the first frame of each phase and whenever a joint action started, stopped or changed. Angles were measured by protractor. A check of reliability of the measurements was made by repeating 100 of them after a lapse of two weeks and correlating the two sets of measurements. Since an r of .97 was found, the technique was considered reliable.

The angle of take-off was measured in the last frame in which the feet were in contact with the ground just before the body was in the air. The angle used was that found between the horizontal, and a line passing through the center of gravity of the body and the point of contact with the ground. Similarly, the angle of landing was measured in the first frame in which the feet were again in contact with the ground.

Means of the angle measurements at the hips, knees, and ankles were computed for the skilled and for the non-skilled performances. The means were considered characteristic of the group when at least six of its members had performed the action. Characteristic likenesses between the two groups were evidenced when the means varied by less than 15 degrees. Means differing by 15 degrees or more indicated characteristic differences between the groups. Statistical procedure was not used since the performances used in this study were not random samples.

The duration of each phase of the movement was based upon the percentage of the film it consumed. Means of the percentages were computed for each

group of performances and the differences between them found. A difference of ten or more in the percentage means of the two groups was considered a characteristic difference in duration of movement. Differences of less than 10 per cent were considered as likenesses. The durations of the various joint actions within each phase of the movement were computed and compared in the same manner.

Sequences of joint actions were studied to discover likenesses occurring in six or more performances of either group. Comparisons were then made between the groups.

Likenesses in the excursion of the arms and the temporal relationships of the arm movements to those of the major body joints were designated as arm movement patterns. The frequency of use of these patterns by each of the groups of performers was noted and compared.

Presentation and Interpretation of the Data

In order to visualize the findings, the measurements of each performance were represented graphically. However, only graphs of the means of measurements are given in this report of the study, the graph of skilled performers appearing in Figure I, and that of the non-skilled in Figure II. It will be noted that the three phases of the jump are indicated by vertical lines. Percentages at the top of the figure designate the part of the whole movement which was consumed by each of its phases. The duration of each action is represented on the horizontal axis, the percentage of the phase consumed by an action being indicated along its charted course. The arm movements are given at the bottom of the figures.

DIFFERENCES OCCURRING DURING PHASE I

From Figures I and II it can be seen that during Phase I differences in amount of hip and knee flexion between the skilled and non-skilled were not large enough to be considered characteristic differences in this study. However, ankle flexion differed by 17.6 degrees (26.3° — 8.7°), the skilled showing the greater amount of flexion. No major difference was found between the hip angles attained by the two groups of performers before extension was started (72.7° — 81.8°). Knee angles were similar also (90.1° — 97.9°). However, at the ankles, a difference of 19.0 degrees (70.6° — 51.6°) occurred.

The skilled were found to have exceeded the non-skilled in extension of the three major joints during Phase I. Their mean hip extension (105.4°) exceeded that of the non-skilled (72.3°) by 33.1 degrees; their knee extension (83°) was 35.4 degrees greater than the 47.6 degrees of the non-skilled; and their ankle extension (76.4°) was 46.6 degrees greater than that of the non-skilled (29.8°).

In comparing the duration of movements of the two groups in Phase I, the skilled used 54.31 per cent of the phase in knee flexion while the non-skilled used only 34.84 per cent. A characteristic difference in percentage of time used in knee flexion (19.47%) was evident. The skilled also consumed 21.48 per cent less of the phase in knee extension (43.68% — 65.16%). No

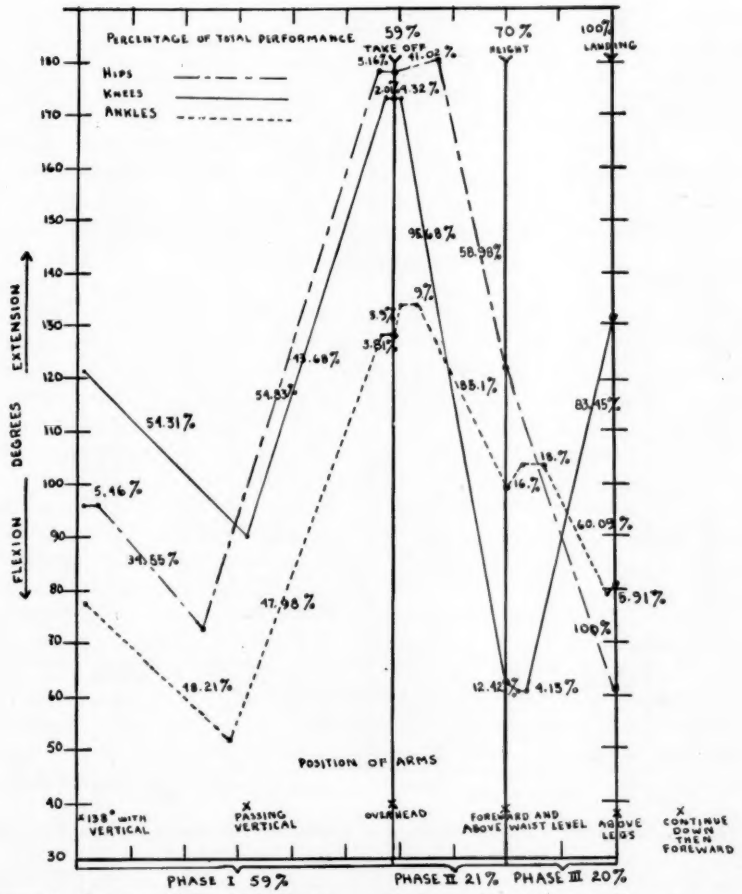

FIGURE I. Extent and Time Relationships of Flexion and Extension in Hips, Knees and Ankles of an Average Skilled Jump.

characteristic differences were found in the duration of hip or ankle action. Thus, during Phase I, the skilled characteristically had greater ankle flexion, consumed more time in knee flexion, and extended the knees a greater amount during a shorter proportion of time. Greater amounts of extension in the hips and ankles were also found to be characteristic of the skilled performances.

DIFFERENCES OCCURRING DURING PHASE II

In the ascending phase of the flight, a difference of 18.3 degrees (58.5° — 40.2°) was found in the amount of flexion at the hips, the skilled having the

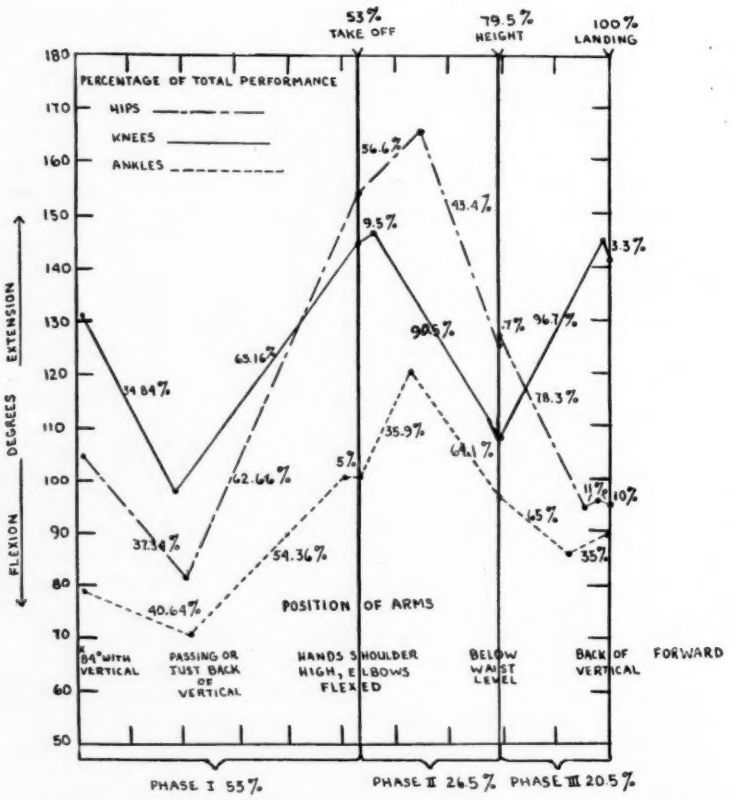

FIGURE II. Extent and Time Relationships of Flexion and Extension in Hips, Knees and Ankles of an Average Non-Skilled Jump.

characteristically greater flexion. A 9.8 degree difference (33.5° — 23.7°) occurred at the ankles. However, the 69.2 degree difference in knee flexion (110.6° — 41.4°) was characteristically greater. The action brought the knees of the skilled to a tucked position having a mean angle of 45.9 degrees smaller than that of the non-skilled (62.5° — 108.4°).

In Phase II, the skilled spent characteristically less time than did the non-skilled in extending the hips and the ankles. Figures I and II show that the hip extension of the skilled used 15.58 per cent less of the phase (41.02% — 56.6%) than did that of the non-skilled, and that their ankle extension used 30.0 per cent less (35.9% — 5.9%). The proportions of time taken in flexing movements of hips and ankles during this phase were also characteristically

different for the two groups, the skilled using the greater proportion of time for the flexing movements. It will be noted that the skilled held the ankles without movement for nine per cent of Phase II. The holding of a position occurred more frequently for the skilled performers than for the non-skilled.

DIFFERENCES OCCURRING DURING PHASE III

Characteristic differences occurred in the extent of hip and ankle flexion and in knee extension during the last phase of the jump. In hip flexion, a 29.3-degree greater amount was found in the skilled performances (60.6° — 31.3°) and they achieved a 34.6-degree smaller angle at the hips when the landing was made (60.9° — 95.5°). Ankle flexion by the skilled (24.7°) exceeded the 10.6 degrees of flexion in the non-skilled by 14.1 degrees. Average angles at the ankle when the landing was made were 80 degrees for the skilled and 89.8 degrees for the non-skilled. The skilled exceeded the non-skilled in amount of knee extension by 33 degrees (69.9° — 36.9°). The angle at the knee at the time of landing was 130.6 degrees for the skilled and 141.7 degrees for the non-skilled, a difference of 11.1 degrees.

In Phase III, characteristic differences occurred in the duration of knee extension, hip flexion, and ankle extension and flexion. When the two groups were compared, the skilled was seen to have consumed 13.25 per cent less of Phase III in knee extension (83.45% — 96.7%); 21.7 per cent more of the phase in hip flexion (100% — 78.3%), and 13.09 per cent less in ankle extension (21.91% — 35.0%). Ankle extension occurred at the beginning and end of Phase III for the skilled, while this action took place only at the end of the phase for the non-skilled.

The average angle of take-off of the skilled (48.4°) was characteristically smaller than that of the non-skilled by 20.3 degrees. The average angles of landing of the groups (59.1° and 73.1°) differed by 14 degrees, the skilled having the smaller angle.

ARM MOVEMENT PATTERNS

One arm movement pattern was found to be characteristic of the skilled performers since it was used by six of the ten subjects. In Phase I of this pattern, the almost fully extended arms were swung downward from a position of high extension in rear and above the flexed trunk. The arms passed the vertical as the knees reached their deepest flexion in Phase I. The swing continued forward and upward, the elbows flexing slightly as the arms passed shoulder height. They reached their highest point overhead, or just in front of the head, at the time of the take-off. Most of these jumpers held the arms in the high position for a few frames at the beginning of the second phase. After this, the arms were extended forward and downward and attained a position in front of the body about shoulder level at the time the center of gravity of the body was at its highest point in the air. During Phase III, the arms continued downward and were extending forward just above the legs when the landing occurred.

Many more patterns were used by the non-skilled, and while no one could be considered characteristic of the group, the essentials of one pattern were used by three performers. In this movement the jumpers had arm positions of medium and low height as the arm swing started forward. After passing the vertical in Phase I, the elbows began to flex and at the take-off the arms reached their highest point, attaining shoulder height only. In Phase II, by the time the center of gravity of the body was at the highest point of its flight, the forearms were almost vertical again with the upper arms slightly back of the body line. During the third phase, the arms continued backward and were in rear of the body at the time of landing.

DURATION OF THE PHASES

In comparing the skilled and non-skilled groups as to the percentages of the duration of the whole jump spent in each of the three phases, no differences large enough to be considered characteristic in this study were found. However, it will be noted that the skilled used 6 per cent more time in Phase I (59% — 53%) and 5.5 per cent less time in the second phase (21% — 25.6%). The difference in duration of Phase III was .5 per cent (20% — 20.5%).

SEQUENCE OF STARTING JOINT ACTION

In Phase I, the skilled started extension in the hip joint whereas extension began almost simultaneously in all three joints in the non-skilled movement. In this phase, the skilled are seen to have continued knee flexion after hip and ankle extension had started.

Summary of Results

CHARACTERISTIC LIKENESSES

The general movement patterns of the jump were alike in the two groups. In more than half the performances of each group the arms moved in a downward, then upward direction. The arm movements were also alike in that the arms moved in a downward direction during a part of Phase II when the body was ascending in flight.

Phase I, the application of force for the take-off, consumed over half the time of the whole jump for both skilled and non-skilled jumpers. In both groups the third phase was the shortest of the three although in the skilled performances the duration of the second and third phases were more nearly alike than they were for the non-skilled.

CHARACTERISTIC DIFFERENCES

Before the take-off the skilled characteristically used greater amounts of ankle flexion and of hip, knee and ankle extension than did the non-skilled. The knee extension of the skilled occurred during a shorter percentage of the phase. Characteristic differences were also found in the amounts of hip and knee flexion as the legs were drawn up under the body, the skilled using more flexion. In comparison with the non-skilled, the skilled used greater percentages of Phase II in flexing the hips and ankles.

During the descent of the flight, characteristically greater amounts of hip and ankle flexion and of knee extension occurred in the skilled performances. Hip flexion consumed a larger percentage of the phase for the skilled. Their knee and ankle extension consumed less time than did those actions of the non-skilled.

The skilled achieved smaller angles of take-off and landing than did the non-skilled.

In the arm movements, the skilled had greater extent of movement, held the arms in the high position, moved them in the sagittal plane most frequently and at the moment the feet contacted the ground in landing, the arms were in front and above the legs. Soon after the take-off, the non-skilled brought the arms down quickly, moved them in several planes, and landed with the arms vertically downward or back of the body.

Interpretation and Recommendations

Since the same general pattern of arm and leg movement was found in the two groups, the question arose as to why the extent and timing of the movement differed between them. The mutually affective causes of lack of muscular strength, limited movement experience, and lack of desire to perform should be considered. The non-skilled performer's seeming fear of losing balance suggested the possibility of need for planned movement experience in losing and regaining equilibrium. Greater use of activities requiring extensive movement are proposed.

Studies of other basic activities might suggest further needs in movement experience as well as help to ascertain characteristic likenesses and differences between skilled and non-skilled movement generally.

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(Submitted 11/14/55)

Notes & Comments

NOTES

Complete Heart Block in a Distance Runner

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SEVERAL CASES of complete heart block in successful long distance runners and other athletes have been reported. Szerreiks[1] reported a case of a 21-year-old 10-kilometer race participant who was considered to be a good distance runner. His electrocardiogram showed complete heart block with an auricular rate of 85 and a ventricular rate of 43. The p-p intervals were about 0.7 seconds. Gilchrist[2] reported 11 cases of heart block in which the effect of exercise was studied. The activity consisted of ascending and descending two steps a variable number of times in a given period. In every instance, there was a compensating increase in both auricular and ventricular rates.

Recently, in our laboratory, a cardiorespiratory function evaluation of a 51-year-old male with complete heart block and fixed bradycardia of 26 beats per minute was revealed (Figure I). A chest X-ray revealed an extremely enlarged heart with left ventricular hypertrophy and dilitation. The subject showed a medical history of heart block

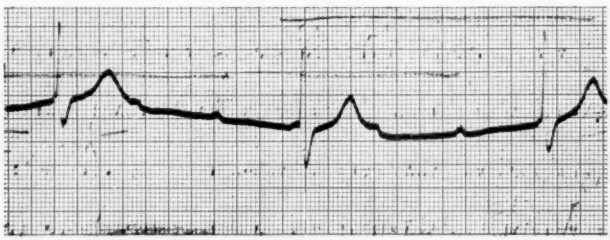

FIGURE IA. Complete Heart Block. Heart Rate of 26/minute at Rest. Auricular Rate 78/minute and Ventricular Rate 26/minute. P—P intervals are about 0.8 seconds.

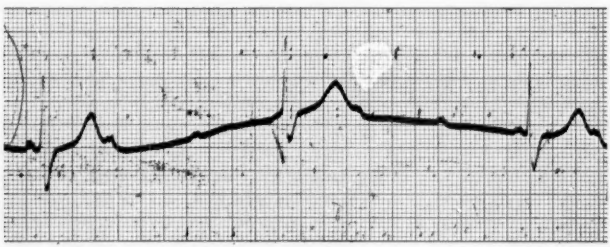

FIGURE IB. Complete Heart Block in Same Patient as in Figure IA. Tracing was taken while patient walked on a motor-driven treadmill at 1.73 mph on a 10% grade. Features of the tracing are essentially the same as the resting electrocardiogram.

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[1]E. Szerreiks, "Ein Fall von Totalem Herzblock ohne Leostungsmiderung bei vollem aktiv Militardienst," *Deutsch Militarartz*, 1: 380, Dec. 1936.

[2]A. R. Gilchrist, "Effects of Bodily Rest, Muscular Activity and Induced Pyrexia on Ventricular Rate in complete Heart-block," *Quarterly Journal of Medicine*, 3: 381-399. July 1934.

and bradycardia since the age of eight. He was, at the age of 22, a champion swimmer and distance runner, having competed in the 1928 Olympic games. During collegiate competition he ran the mile in 4:28.0 minutes.

Under the circumstances of his heart block and response to standard exercise in the laboratory, it would seem impossible that he could increase his stroke volume and cardiac output to meet the energy demands of distance running or swimming at such high levels. Energy expenditure at these levels[3] would call for a cardiac output of at least 20 liters per minute.[4] Extrapolating further, such cardiac outputs would be equivalent to a pulse rate of between 140-200 beats per minute and a stroke volume of at least 134 ml.

As the subject walked on the treadmill, he expended energy from three to four times above his resting level.[5] His oxygen consumption during work was 515 ml/minute/M^2 BSA,[6] and the heart rate remained at 26 per minute throughout the rest, exercise, and recovery periods. At rest his oxygen consumption was 133 ml/minute/m^2 BSA.

This subject was different from those studied by Szerreiks and Gilchrist, inasmuch as he did not experience a compensating increase in ventricular or auricular rate in response to standard exercise. After four minutes of exercise of moderate intensity, the electrocardiogram (Figure IB) had not changed, nor did it change in subsequent recovery.

From his history we are not able to determine whether he received a compensating effect of increased rate when he was a competing athlete. Nevertheless, his compensatory ability to perform work of moderate intensity as he did in our laboratory indicates a phenomenal ability to increase the cardiac output from the secondary circulation—without an alteration in either auricular or ventricular rates—to meet the metabolic demands of energy expenditure by a factor of 3.86 above the resting level.

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[3]L. E. Morehouse, and A. T. Miller, *Physiology of Exercise*, St. Louis: C. V. Mosby Co., p. 240, 1953.

[4]A. Krogh, and J. Lindhard, "Measurements of the Blood Flow through the Lungs of Man," *Skand. Arch. f. Physiol.*, **27**: 100, 1934.

[5]A. O. Beckman Oxygen Analyzer.

[6]Body Surface Area.

Fry Analyzer for Simple and Rapid Respiratory Gas Analysis

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F. E. J. FRY[1] devised an enlarged version of Krogh's micro-apparatus for carbon dioxide and oxygen gas analysis. Since a student can learn to use the Fry Gas Analyzer by following simple directions and can obtain reasonable results after one trial, it is a valuable classroom aid. Each gas sample can be analyzed within ten minutes.

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[1]F. E. J. Fry, "A Simple Gas Analyzer," with an appendix by A. C. Burton and O. G. Edholm, *Canadian Journal of Research*, E **27**: 188-194, June 1949.

This speed allows several determinations of the same sample, and, therefore, the apparatus appears to have research possibilities. Accurate readings can be taken to 1/400th of the total sample analyzed. In comparison, the Haldane Gas Analyzer permits accurate readings to 1/4000th of the total volume analyzed if readings on each instrument are made to the closest quarter of a division.

The method of sample introduction also limits the research value. The sample is injected through a rubber cap on the side arm of the analyzer. In student laboratory work, an oiled hypodermic syringe suffices for a fast and reasonably accurate sample introduction, but, to make such an injection leakproof, a more elaborate and slower method is required.

Modifications could be made to permit finer readings and to safeguard the sample introductions, but they would considerably raise the construction cost and lengthen the operation time. Since the apparatus was designed to be inexpensive as well as swift and simple to operate, such modifications seem contrary to the main purposes of the analyzer.

Below, we compare our own data on cost and accuracy of the analyzer with that of Fry, *et al:*

TABLE 1
Comparison of Gas Analyzer Costs

Cost Breakdown	Fry, et al., 1949	Michigan State University, 1955*
Total Cost:		
24 analyzers	$212.50	.....
18 analyzers	.....	$214.00
Each	8.85	11.90
Detailed Cost:		
Metal Parts	24.80	75.00
Glass Parts	31.00	24.00
Wood	10.00	5.00
Labor:		
Glass Blowing	60.00	25.00
Woodwork	31.00	85.00
Assembly	55.70	

*The construction at M.S.U. is somewhat different from that of Fry, *et al.*, in order to make use of standard laboratory-type supports. The woodwork and assembly were done in the Physiology Department shop and the expenses are estimated. Cost of mercury should be added to both sets of figures. At current prices, this would amount to approximately $3.50 per analyzer.

TABLE 2
Comparison of Gas Analyzer Accuracy

Group	N	% Carbon Dioxide			% Oxygen		
		Mean	SD	Range	Mean	SD	Range
Medical Students at First Trial (Fry, *et al.*)							
Room Air	35	0.31	0.28	0-1.25	20.36	0.52	18.5-21.5
Alveolar Air	25	5.47	1.39	3-8	14.0	1.9	11-16
Junior Physical Education Students at First Trial (Michigan State University)							
Room Air	20	0.63	0.46	0-1.52	20.4	1.1	17.0-21.7
Alveolar Air	17	4.61	1.27	2.99-6.54	15.3	1.7	13.0-17.8

Twenty expired air samples were analyzed on both the Fry and Haldane gas analyzers. The mean difference in per cent carbon dioxide was 0.15 with a standard deviation of 0.18 and range of 0.01 to 0.39. For per cent oxygen, the mean difference was 0.20, standard deviation 0.23, and range 0.00 to 0.49.

Physical Education as a Phase of the College Program of General Education

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THIS QUESTIONNAIRE study was undertaken to determine current practices and changes made in the physical education curriculum owing to the adoption of a program in general education by institutions of higher education.

1. A preliminary screening of institutions having a four-year degree granting program was made.[1] These totaled 1,334 institutions. A further screening eliminated those not reporting a program of general education in whole or in part. A random sample of the remaining 941 institutions was made bringing the total number of the sample to 391 institutions.[2]

2. The results of the questionnaire are based upon the returns of 178 out of the 391 institutions in all parts of the country. This is a return percentage of 45.5 for the 391 questionnaires mailed, or 18 per cent of the original 941 institutions from which the random sample was taken. The limitations imposed by the low over-all percentage of returns should be kept in mind in the interpretation of the following data.

Type of Institutional Control and Changes in the Curriculum

3. Twenty-six per cent of four-year degree-granting institutions in our country are state or municipally controlled. A total of 27 per cent of the returned questionnaires were from institutions so controlled.

4. Twenty-nine per cent of four-year degree-granting institutions in our country are privately controlled. A total of 27 per cent of the returned questionnaires were from institutions so controlled.

5. Forty-five per cent of four-year degree-granting institutions in our country are denominationally controlled. A total of 46 per cent of the returned questionnaires were from institutions so controlled.

6. A total of 340 individual changes were indicated by the institutions returning questionnaires. All of these changes occurred since the adoption of a program in general education in these institutions.

7. State or municipal colleges in this sample numbered 48. These indicated a total of 90 changes for an average change of 1.87 per institution.

8. Private colleges in this sample numbered 49. These indicated a total of 82 changes for an average change of 1.67.

9. Denominational colleges in this sample numbered 81. These indicated a total of 168 changes for an average change of 2.07 per institution.

Requirement and Administrative Control

10. A required program of physical education was indicated by 92 per cent of the sample as part of the general education requirement.

11. The department of physical education falls under the administrative control of the person(s) responsible for the area of general education in 73 per cent of the institutions with a physical education program.

12. The task of planning and reorganizing the college curriculum in general education was carried out with the assistance of members from the physical education department in the same percentage of colleges.

Changes in the Physical Education Program

13. Sixty-five per cent of the colleges indicated no change in the physical education program was necessary since the college adopted a program of general education.

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[1]U. S. Department of Health, Education, and Welfare. *Education Directory, Part 3*, "Higher Education," 1953-54. Washington, D. C.: U. S. Govt. Printing Office, 1953, p. 8.

[2]Choice of sample based on table of random numbers in Helen Walker and Joseph Lev, *Statistical Inference*. N. Y.: Henry Holt and Co., 1953, pp. 484-5.

14. Thirty per cent reported no change necessary in the scope and nature of the physical education program since the adoption of a program of general education.

15. There were, however, 340 individual responses to the last ten questions that suggested possible changes that might have occurred in the physical education program since the adoption of a program of general education by a college.

16. The greatest change indicated relates to the application of credits earned in physical education to graduation and honors. This finding is significant in that it is a clear indication of whether or not a college considers physical education an integral part of the college program of general education. In addition it points to the fact that 30 per cent of the colleges considered physical education important enough to the general education of all students to change the general education requirement to include credits earned in physical education.

17. Six per cent of the sample abolished the physical education requirement and substituted activities on an elective basis. In direct contrast to this, physical education requirements were increased by 13 per cent of the sample and the number of earned semester hours was increased by 17 per cent of the sample. Half of the latter institutions increased the number of earned semester credits or points from none to as many as six.

18. The important area of knowledge, understanding, and appreciation of physical education also has been included in the physical education program as a direct result of the initiation of a program in general education by 25 per cent of the sample.

19. An increase both in the kind and amount of co-physical education and coeducational recreation was indicated by 23 per cent of the sample. Greater use of community resources was indicated by 20 per cent of the sample.

20. Fifteen per cent of the colleges changed control of intercollegiate athletics from autonomous, self-supporting basis to inclusion in the total educational picture as an integral phase of the general education offerings of the college.

21. Fourteen per cent of the colleges included physical education recreational activities in the intramural and extramural program, owing to the adoption of a program of general education.

22. Seven per cent of the sample indicated that students now participated in setting their own goals and planning a program of activities to meet them. This small response may be traced to two factors. First, this is a concept which is basic to general education. As such, it would seem to follow that because this concept is fairly new on the educational scene methodology has not caught up to theory as yet. Second, many programs of physical education attempted to do this before the term "general education" as such came into popular usage in higher education. This latter point was stressed by many of the individuals who filled out the last page of the questionnaire under the heading relating to individual comments. This point is further emphasized by 30 per cent of the colleges who indicated that no change in the nature and scope of physical education was needed and 65 per cent who indicated that no program changes were necessary since the college adopted a program of general education.

Conclusions

23. Physical education is considered an integral part of the general education offerings of 92 per cent of the institutions in this sample.

24. Physical educators share in the planning and reorganizing of the general education curriculum in 73 per cent of the institutions in this sample.

25. The type of institutional control does not appear to influence the amount of change to any appreciable degree in this sample.

26. College physical education programs have undergone many specific changes since the adoption of a program of general education by a specific college.

Some Precautions in Exercise Metabolism Experiments

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THE USE OF the wet-test meter for measuring gas volumes is an accepted routine laboratory technique. When Douglas bags are employed for collecting exhaled air, they are evacuated by a mechanical pump or are frequently squeezed to force the gas through a wet-test meter. In some instances, even during vigorous exercise, experiments have been conducted with the subjects exhaling directly through the wet-test meter. Wet-test meters, however, are generally not designed to handle gas flows of this magnitude. The models most commonly employed in this country are those with a catalogued maximum flow capacity of approximately 9 liters per minute. Larger wet-test meters are available, but even the very largest instruments rarely, if ever, are designed for flows beyond 40 liters per minute.

The purpose of this study was to investigate the accuracy of procedures used in the handling and measuring of respiratory gas volumes. More specifically, the following were investigated: (1) The accuracy of wet-test meters within and above calibrated rates of flow; (2) The effects of manually squeezing Douglas bags for metering purposes; (3) The respiratory resistance encountered in a Douglas bag during filling to above rated capacities.

Wet-Test Meter Calibration: Constant Flow

Calibration data on two of these commonly used wet-test meters are reported: One with a catalogue listed maximum of 9.1 liters per minute (wet-test meter *B*) and one with a catalogue listed maximum of 9.4 liters per minute (wet-test meter *A*). The two instruments were calibrated initially by metering through them a volume of air that was displaced in a large carboy by an accurately measured volume of water. The rate of flow through the wet-test meters in each trial was between 2.3 and 2.4 liters per minute. The recorded volumes on these four runs in relation to the actual volume were found to have per cent errors of 0.25, 0.15, 0.00 and 0.21; the mean error being 0.15%. As a further check on wet-test meter *B*, air was pumped directly through both instruments, *A* and *B*, at approximately the previously listed calibration rate (about 3 liters/min.) to determine differences. The average difference was .006 liters per minute (Table 1). These errors were so small as to be negligible and were considered to be experimental errors.

TABLE 1
Pumping Air Through Two Wet-Test Meters

	Rate Meter *B* (1/min.)	Rate Meter *A* (1/min.)	Difference	Per Cent Difference	Correction Factor
	2.51	2.50	—0.01	—0.39	1.00
	3.48	3.57	+0.09	+3.21	0.97
	2.26	2.23	—0.03	—1.33	1.01
	2.57	2.51	—0.06	—2.33	1.02
	2.62	2.62	0.00	0.00	1.00
	2.76	2.76	0.00	0.00	1.00
	2.60	2.60	0.00	0.00	1.00
	2.46	2.42	—0.04	—1.62	1,02
Sum	21.26	21.21	—0.05	—2.46	8.02
M	2.66	2.65	—0.006	—0.308	1.00

Wet-Test Meter Calibration: Varying Rates of Flow

In the determination of the calibration curves for the two instruments, air was first pumped into a Douglas bag (150-liter capacity) through the wet-test meter at a rate close to that used in the air displacement calibration. After the volume registered on the wet-test meter was recorded, the air was pumped out of the Douglas bag and back

through the wet-test meter at the recorded rates of flow. The actual flow was calculated by dividing the known volume in the Douglas bag by the time (recorded by stop watch) required to pump it out.

The calibration data are presented in Figure I. Both instruments recorded fairly accurately to their rated maxima, but beyond this there is considerable difference in their reliability. It is obvious, however, that neither instrument records faithfully very great air flows—certainly not those which would be encountered during exercise of even moderate severity. It should be remembered that although the volume of expired air during rest is roughly 7 liters per minute (1) during half of the time, roughly speaking, the subject is inhaling. Hence his mean rate and certainly his maximum rate of flow while exhaling would be considerably higher than 7 liters per minute. During exercise, the exhaled air could conceivably reach a flow in the neighborhood of 200 liters per minute, since volumes of exhaled air have reached 100 liters in a minute (1).

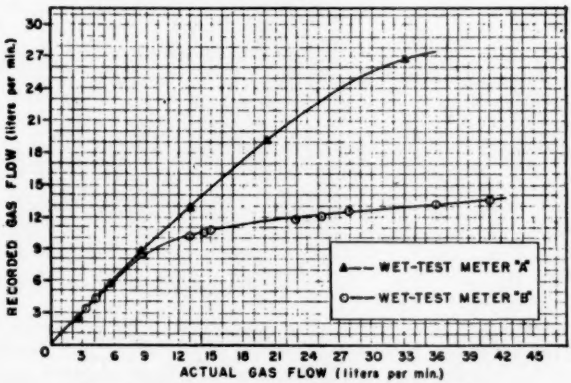

FIGURE I. Wet-Test Meter Calibration Curves.

Effects of Squeezing the Douglas Bags

It is a rather common practice, as mentioned previously, to squeeze the Douglas bag, forcing air through the wet-test meter, to measure its volume. Errors involved in this process were next studied. Actual volumes were secured by pumping air into the Douglas bag at rates from 3.16 to 3.95 liters per minute. The bags were squeezed in the usual manner without exerting an unusual amount of pressure. The errors of 12.3, 10.3, 24.7, and 23.0 per cent (Table 2) are relatively large. This does not appear to be a satisfactory technique with wet-test meters of the capacity of these instruments, as the errors are large and inconsistent. It would appear advisable to use a mechanical pump to evacuate the bags or tissot tank at a rate which could be handled accurately by the wet-test meter. The last column in Table 2 represents the air left in the bag after it has been squeezed as completely as possible.

TABLE 2
Error In Recorded Gas Volume When Douglas Bag Is Squeezed Manually

Wet-test Meter	Actual Volume (*l.*)	Recorded Volume (*l.*)	Error (*l.*)	Per Cent Error	Residual (Secured by) Evacuation with Pump) (*l.*)
A	98.13	86.09	12.04	12.3	0.54
A	106.78	95.78	11.00	10.3	0.54
B	101.22	76.20	25.02	24.7	0.65
B	106.13	81.73	24.40	23.0	0.31

Resistance in Douglas Bag

There has been some concern in exercise experiments that the weight and distention of of the Douglas bag causes resistance in the system which would affect the results. Resistance below 20 mm. of water is not generally considered to be a significant factor (2).

Two repetitions of an experiment were carried on to investigate the resistance to be expected at various volumes in the Douglas bag (Figure II). To secure the curve, a water manometer was inserted between the wet-test meter and the Douglas bag and air was then pumped through the wet-test meter at a rate of 2.8 and 3.3 liters per minute. The Douglas bag was laid on its side so the maximum weight of the bag could exert pressure on the enclosed air. Periodically, volumes on the wet-test meter and water pressure on the manometer were read simultaneously and recorded. It appears clear that no serious resistance occurs unless the 150 liters capacity is exceeded, and that resistance caused by the weight of the bag is negligible.

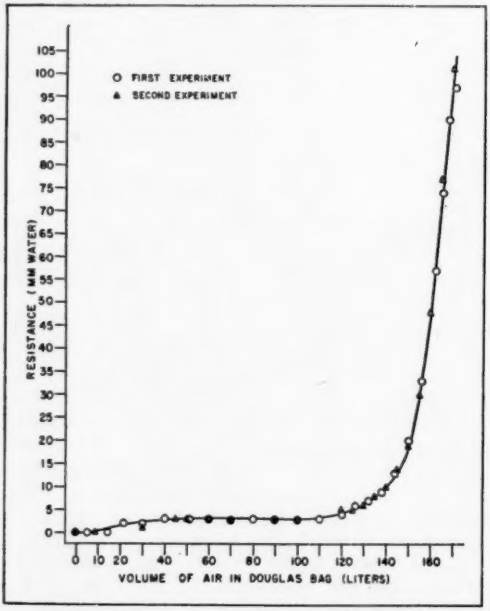

FIGURE II. Resistance in Douglas Bag at Various Volumes.

Summary

An investigation was made of the accuracy in handling gas volumes in exercise metabolism experiments. Two wet-test meters were found to be accurate to their recorded flow capacities but to vary considerably at higher rates. The technique of squeezing Douglas bags for metering was found to introduce errors up to 25 per cent. It appears advisable to use a mechanical pump to evacuate the bags or a tissot tank at a rate within the calibration of the wet-test meter. Negligible resistances were found in filling Douglas bags to their recorded capacities. The need for accurate calibration of gas volume measuring instruments was indicated.

1. SCHNEIDER, E. C., AND P. V. KARPOVICH. *Physiology of Muscular Activity*, Philadelphia: W. B. Saunders Co., 3rd ed., 1948.
2. MATTHES, H. V. "Die Bedeutung des Atemwiderstandes für die Messung des Respiratorischem Stoffwechsels." *Arbeitsphysiologie*, **11**: 117-128, 1946.

Research Abstracts

Prepared by the Research Abstracts Committee of the National Council of the Research Section, PAUL A. HUNSICKER, Chairman

Anthropology

38. ALLBROOK, DAVID BENJAMIN. Changes in lumbar vertebral body weight with age. *American Journal Physical Anthropology,* **14:** 1 (Mar.).

In a series of East African skeletons the anterior and posterior height of lumbar vertebrae was measured. The combined lumbar vertebral body height was longer in males than in females. The point of contra-flexture lay between L3 and L4, and was uninfluenced by age, sex, or tribe, but was influenced by the number of prevertebral segments. In male skeletons, there was a significant increase in both anterior and posterior vertebral body height in the age range 20-45 years. This was not apparent in female skeletons.—*The Wistar Institute.*

39. DAMON, ALBERT, and ROSS A. MCFARLAND. The physique of bus and truck drivers. *American Journal Physical Anthropology,* **13:** 4 (Dec.).

Occupational anthropology has been neglected in the United States despite its bearing on human biology, engineering, medicine, psychology, and vocational placement. Previous studies disclose some constant occupational differences in physique. Differences among apprentices in various trades, among workers in jobs requiring similar energy expenditure, and among good, fair, and poor workers within one occupation emphasize selection and adaptation rather than direct influence of work on physique. Some 379 heavy-vehicle drivers, averaging 36.8 years of age and 10 years as professional drivers, were measured and somatotyped. They included 103 bus and 104 truck drivers from New England and New York, 69 Texas truckmen, and 103 champion truckmen representing every state. Compared to Americans in general, the three groups of regular drivers combined were about as tall, but heavier and stockier, with larger chests, possibly more endomorphy, and decidedly more meso-, less ecto-, and less gynandromorphy. However, there were no physical differences between 2,500 Army drivers and their parent population of 25,000 soldiers of World War II. The champions were younger and taller than regular drivers, with broader shoulders, greater sitting height, longer forearms, shallower abdomens, and even more mesomorphy.—*The Wistar Institute.*

Nutrition

40. DRYDEN, LESLIE POWELL, ET AL. Experiments on the comparative nutritive value of butter and vegetable fats. *J. Nutrition,* **58:** 2 (Feb.).

Experiments have been described dealing with the relative nutritive value of butterfat and vegetable fats. Comparisons at four different fat levels have been made between butterfat and corn oil incorporated into lactose-containing diets fed to weanling rats. Growth on the butter rations increase with increasing fat level. Growth on the corn oil rations showed the same tendency but not to a significant degree. Only at the higher fat levels was there evidence to indicate that butter promoted weight gains superior to corn oil. Supplementation of the butter diet with linoleate had no effect. A comparison between the growths of rats fed summer or winter butter at three different fat levels showed no differences at any level over an 18-week period. Comparisons were made be-

tween butterfat, margarine fat, and corn oil incorporated into sucrose rations containing 28% fat. Butterfat and margarine fat were found to promote significantly better growth of weanling rats than corn oil but only during the first three weeks of the experiments and when sulfathalidine was included in the ration.—*The Wistar Institute.*

41. National Dairy Council. Soil, food, and human health. *Dairy Council Digests,* **27**: 4 (Mar. 1956).

The possible relationship of soil composition to human nutritional diseases is discussed with special references to mineral imbalances, iodine deficiency, nutritional anemia, and minerals in bone and teeth. The paper points out that human anemias are not traceable to soil deficiencies of iron, copper, or cobalt but to choice of food, stress from heightened physiological needs during growth and childbearing years of women, and excessive excretion or faulty absorption of iron as a result of parasites, wounds, or illness. Endemic goiter results from iodine deficiency in soil, water, and crops. Rickets, and other diseases of bones and teeth involving deficiencies or imbalances with respect to calcium, phosphorous, vitamin D, or other organic nutrients are more related to dietary habits than to soil composition.—*Paul Hunsicker.*

42. Swendseid, Marian, et al. Amino acid requirements of young women based on nitrogen balance data. *J. Nutrition,* **58**: 4 (Apr.).

The amounts of the sulfur-containing amino acids required to maintain nitrogen equilibrium in 8 healthy young women have been determined. When these subjects were placed on a diet containing 7 to 8 gm of nitrogen in the form of peanut protein, the essential L-amino acids, and glycine, it was found that the cystine-methionine requirement was 350 mg or less for 5 subjects, 450 mg for two subjects and 550 mg for one subject.—*The Wistar Institute.*

43. Tidwell, Herbert C. The effect of choline, methionine and ethionine on fat absorption. *J. Nutrition,* **58**: 4 (Apr. year).

The effect of various substances on the rate of fat absorption in rats was measured both by the increase in chylomicronemia and by the recovery of the unabsorbed ingested fat from the intestinal tract. The inability of the injected choline to aid emulsification while increasing the rate of fat absorption suggests that lecithin as well as choline is otherwise involved in the absorptive process. The fat supplements of prostigmine and mecholyl failed to increase the rate, indicating that the effect of choline on the process cannot be a cholinergic one. Values slightly higher than the controls were obtained for the rates of fat absorption in each experiment with the methionine supplement. This result might be attributed to a failure to supply more physiological amounts of methionine continuously or to a synthetic process too slow to produce sufficient choline to be more effective. The former possibility was suggested by the markedly increased absorptive rate when an ethionine supplement was given since its ingestion has been associated with the liberation of a considerable amount of free methionine. The reported rapid incorporation of free choline into lecithin along with these results would suggest that a likely role of choline in accelerating fat absorption is that of promoting phospholipid formation.—*The Wistar Institute.*

Physiology

44. Bengtsson, Elias. Working capacity and exercise electrocardiogram in convalescents after acute infectious diseases without cardiac complications. *Acta Medica Scandinavica,* **154**: 359-373 (1956).

The study reports the findings on 34 children and 34 adults between the ages of 6 and 43 years, of ordinary physical fitness and body weight and without cardiac or other

complications. They were hospitalized for various infectious diseases, the duration of illness averaging 2.5 and 3.6 weeks respectively and the duration of bed rest 2.3 and 2.8 weeks respectively. Working capacity was tested on an electric bicycle ergometer. Electrocardiograms were taken in bipolar and unipolar extremity leads before and after exercise. Results were compared with those in a previously reported normal series which had been partly investigated in the same way and with those of three athletes and one person with a very poor degree of physical training.

At neither of the examinations did the working capacity in children differ significantly from that of normal cases. In adults the working capacity differed significantly from that of the normal. The decrease of the working capacity was apparently correlated to a decrease of the heart volume. The exercise EKG showed, in comparison with normals, no changes except with regard to the T wave variations from the resting values.

In comparison with other convalescents, the working capacity in relation to body weight and, notably, heart volume was significantly higher in a few highly trained athletes, but significantly lower in one woman with psychosomatic disturbances who, prior to the infectious disease, had an extremely poor degree of physical fitness.—*Paul Hunsicker.*

45. Clarke, H. Harrison, et al. Strength decrement index: a new test of muscle fatigue. *Archives of Phys. Med. and Rehab.* 376-378 (June 1955).

The authors propose the Strength Decrement Index (SDI) as a test of muscle fatigue. The formula for its computations is:

$$SDI = \frac{Si\text{-}Sf}{Si} \times 100$$

Where: Si = Initial strength: taken before exercise
Sf = Final strength: taken after exercise

The SDI was utilized to determine the fatigue effect on 11 muscle groups in marching and carrying military packs under field conditions. Reference is made to the use of the SDI in conjunction with five weeks of training for a 200-yard swim.—*Paul Hunsicker.*

46. Hellebrandt, F. A., and Sarah Jane Houtz. Mechanisms of muscle training in man: experimental demonstration of the overload principle. *Physical Therapy Review,* **36:** 371-383 (June 1956).

The study presents an experimental demonstration of the overload principle and evaluates the efficacy of some of the clinical technics of applying strength developing exercise. Eight male and nine female subjects were used in a total of 620 experiments encompassing seven different training procedures.

The following conclusions are advanced: (1) strength and endurance increase when repetitive exercise is performed against heavy resistance; (2) the slope gradient of the training curve varies with the magnitude of the stress imposed, the frequency of the practice sessions, and the duration of the overload effort; (3) mere repetition of contractions which place no stress on the neuromuscular system has little effect on the functional capacity of the skeletal muscles; (4) the amount of work done per unit of time is the critical variable on which extension of the limits of performance depends; (5) the speed with which functional capacity increases suggests that central nervous system changes contribute an important component to training; (6) the ability to develop maximal tension appears to be dependent on the proprioceptive facilitation with which overloading is associated; and (7) no evidence was forthcoming in support of the validity of currently popular technics of administering progressive resistance exercises clinically.—*Paul Hunsicker.*

Psychology

47. Rexford, Eveoleen N., Maxwell Schleifer, and Suzanne T. Van Amerongen. A follow-up of a psychiatric study of 57 anti-social young children. *Mental Hygiene*, **40**: 196-214 (April 1956).

Forty-eight anti-social young children from 6 to 12 years of age who had received psychiatric treatment from 1947 to 1952 were the subjects of a follow-up study in 1954. Nine other children had been studied diagnostically. The follow-up study indicated that the psychiatric treatment was effective in two-thirds of the 48 cases. Based on their study of the data and the subjects, the authors feel that anti-social children suffer from a severe character disorder which can not be effectively improved by superficial measures such as recreational activities.—*Bruce L. Bennett.*

48. Thomas, Lawrence G. Leisure pursuits by socio-economic strata. *Journal of Educational Sociology*, **29**: 367-77 (May 1956).

The author reviewed research evidence on socio-economic differences in leisure pursuits as a guide for educational policies in the schools. It was found that economically superior families possess better equipment for leisure and probably find more recreation at home. Poorer families tend to escape the home environment. However, differences in taste are probably more significant than differences in purchasing power in determining leisure patterns of high and low socio-economic groups. Social distance between various classes tends to keep lower class children out of recreational organizations such as the Boy Scouts, Camp Fire Girls, and YMCA. The author observes that although teachers will probably endorse leisure preferences of upper economic groups, these should not necessarily be imposed on other groups as their own patterns may be more valid for them. There was no special reference made to sports or games.—*Bruce L. Bennett.*

49. Watson, George, Is mental illness mental– *Journal of General Psychology*, **41**: 323-34 (Apr. 1956).

Experimental evidence on the relation of nutritional factors to the deterioration of personality indicates two principal points: (a) some states of functional mental illness may originate from nutritional deficiencies, and (b) these cases of functional mental illness may be relieved by nutritional therapy. Some types of mental illness hitherto considered "functional" in origin have a physical basis of a biochemical nature and are not directly due to psychological trauma or conflict. Psychological stress may cause nutritional displacement and nutritional displacement causes mental illness. Supportive psycho-therapy may relieve some of the psychological pressure and be of indirect value, but psychoanalysis alone without nutritional correction may make the condition worse by adding more stress. Knowledge of the precise psychological trauma and conflicts of the past is of no interest in those cases of psychoneurosis which are characterized by sub-clinical nutritional deficiencies.—*Bruce L. Bennett.*

International Research Council

Hamilton Cameron, M.D., New York City, recently announced the incorporation of the International Research Council, first world-wide medical confraternity for dissemination of knowledge concerning aphasias associated with hemiplegia.

Dr. Cameron's "Hand Talking Chart," devised in 1943 during his convalescence from an attack of hemiplegia and total aphasia, is offered gratis as a practical clinical aid. For gratis copies of the chart and detailed information on the International Research Council, address *Dr. Hamilton Cameron, General Director, 601 W. 110th St., New York City 25.*

Guide to Authors

IN LINE WITH the over-all goal of making Association publications yield the greatest value to the individual and the profession, the following is a guide for the preparation of manuscripts for the *Research Quarterly*, recognizing general techniques employed by research publications.

Article Manuscripts

Manuscripts should be sent to the Editor (AAHPER, 1201 Sixteenth Street, Northwest, Washington 6, D. C., who will see that each one is read by at least three members of the *Research Quarterly* Board of Associate Editors. On the basis of the three reviews, the Editor will advise the author as to the suitability of the paper or the desirability for revision. Papers are not judged by arbitrary standards but on their content of new research results in the field of physical education, health education, and recreation, presented with the greatest brevity compatible with scientific accuracy and clarity (see October 1951 *Quarterly*, pp. 392-4).

Since three members of the Board of Associate Editors review an article, it is requested that three clear copies of the manuscript be submitted in order to facilitate reviewing. A fourth copy of the article should be retained.

Typewritten manuscript should be double-spaced on white paper of ordinary weight and standard size (8½ x 11 inches). A brief abstract of the article, 100 words or less, should be typed double space on a separate sheet. See abstracts at head of *Quarterly* articles for style.

The sheets of manuscript should be kept flat and fastened with clips which can be removed easily. The pages of the typewritten copy should be numbered consecutively in the upper right-hand corner. Paragraphs should be numbered consecutively throughout the manuscript.

Notes and Comments

Notes on minor research and on apparatus, *objective* critical comments, and summaries of status suveys will be printed in the Notes and Comments section. Note that simple status surveys are no longer acceptable as regular *Quarterly* articles, by decision of the Research Council. Such studies will therefore be published in brief form (300-500 words) under Notes and Comments.

Headings

The article should be arranged so as to indicate relative values of heading and subheadings.

Usually four gradations are sufficient: (a) article title, (b) first subhead appearing in boldface aligned left on page (underscored in manuscript with wavy line) (c) second subhead (if necessary) appearing in small caps aligned left on page, (d) third subhead, to appear in italic (underscored in manuscript), not centered, but run in at the beginning of the paragraph or section.

All headings should be typed in lower case with initial capitals, except for (c) above, which should be typed in capital letters.

FOOTNOTES

Footnotes are not to be used for references or literature citations. They are rather used for the purpose of acknowledgment, special explanation, supplementary information, etc. (*See examples below.*)

Type footnotes (if any) on separate sheets, as many footnotes as convenient being written on a sheet. Footnotes should be numbered from 1 up for each article; a corresponding numeral appearing in the text. Asterisks should not be used.

Examples of Footnotes:

[1] This study was made under the direction of Dr. Arthur T. Slater-Hammel in the Research Laboratories, School of Health, Physical Education, and Recreation, Indiana University, Bloomington, Indiana.

[2] All measurements of the hand were recorded in centimeters and height was recorded in inches. The hand measurements were taken by Everett and reliability coefficients of above .90 were found for each measurement used in the study.

[3] For their wholehearted co-operation in facilitating collection of the data, special gratitude is extended to Superintendent Clarence Hines and the 1950-51 principals of the Adams, Condon, Edison, Francis Willare, Harris, Howard, Lincoln, River Road, and Whiteaker schools.

Documentation

CITATIONS OF LITERATURE

Citations of literature should be segregated alphabetically by author's last name at the end of each article, under the caption of "REFERENCES." *Do not treat them as footnotes.* (*See above.*)

The literature citations, listed alphabetically, should be numbered consecutively, their location in the text being indicated by corresponding numbers written in full size and enclosed in parentheses: for example, (1) (2, 3). If there are several references in the text to a citation, the specific pages may be indicated thus: (1, *p. 117*), (1, *pp. 162-3*).

A uniform style should be maintained in writing citations. Do not enclose titles of chapters and articles in quotation marks. Italicize (underscore in manuscript) names of books and periodicals, bulletins, etc. (*See examples below.*)

Uniform sequence of data shoud be observed, as follows: *For a book*—Author's name (last name first); title of article or chapter; name of book; place of publication; publisher; year date. *For a periodical*—Author's name (last name first); title of article or chapter; name of periodical; volume number; inclusive page numbers; year date.

Examples of References Appearing at End of Article:

1. American Association for Health, Physical Education, and Recreation. Suggested platforms for health education. *Journal of the American Association for Health-Physical Education-Recreation,* **18**:436 (Sept. 1947).
2. American Association of School Administrators. *Health in Schools.* Revised edition. Washington, D. C.: the Association, a department of the National Education Association. pp. 266-7.

3. DEAVER, G. G., Exercise and heart disease. *Research Quarterly*, **26**: 24-34, 1939.
4. OGDEN, JEAN, AND JESS OGDEN. Small Communities in Action. New York: Harper & Brothers, 1946.
5. POTTER, JOHN NICHOLAS. *Physical Fitness of Junior High School Boys.* Unpublished Master's thesis, University of California, Berkeley, 1942.

Tabular Matter

Each table should have a descriptive heading and should be specifically referred to in the text by number, *e.g.*, "Table 10," etc., never as "the above table" or "the following table." Number tables from 1 up for the entire manuscript, using Arabic numerals. Do not duplicate data by giving it in *both* tables and graphs.

Tables should be double-spaced typewritten, like the rest of the material in the manuscript. They should be typed on separate sheets, as the printer will set them on a different machine from the one used for the text matter. If a table continues on a second sheet, it is not necessary to repeat the boxheads, since the printer will repeat from the original boxheads, when necessary.

The word "TABLE" should be written in capital letters, as: "TABLE 1"; the table title should be written in lower case letters with initial capitals, and centered over the table. Tables should be ruled as desired, except that no rules will appear at the extreme right and left edges of the table. No double rules are to be used, unless necessary for clarity.

Well-known statistical formulas should be omitted. Extensive tabular material, raw data, and appendixes should not be printed; the author can mention in a footnote that he will supply such material in mimeographed form on request.

Illustrations

Illustrative material is of two types: pen and ink drawings, which are reproduced by the line engraving process; and photographs, wash drawings, stipple drawings (in short, anything containing shading), which are reproduced by the halftone process.

Line engravings are always treated as text figures and should be so designated. All drawings should be made with India ink, preferably on white bristol board plate, 1 ply or 2 ply, which is sufficiently transparent to permit tracing if back lighting (e.g., a window pane) is used. Avoid graph paper for the reproduction copy, as the printing interferes with proper inking and the paper permits no corrections. Sometimes it is desirable to ink in the principal guide lines so that the curves can be more easily read. Good examples of graphs can be seen in *The Research Quarterly* for October 1953, pages 332 and 366.

Lettering should be plain and large enough to reproduce well when the drawing is reduced to the dimensions of the printed page (4⅛ x 7 inches). Most figures can be advantageously drawn for a linear reduction of one-half or one-third. Be sure to draw the lines heavy enough so that they will not be overly thin after reduction. Explanatory lettering should be included within the chart. Typewritten lettering does not reproduce well; it is much better to use a LeRoy or similar lettering device.

Care should be taken not to waste space, as this means greater reduction and a less satisfactory illustration. Often it is possible to combine several curves in one figure and enable the reader to make comparisons.

Halftones are treated as figures and should be so designated. Frequently, several halftones can be grouped to form an attractive full page, in which case they should be numbered consecutively, in Roman numerals. Photographs should be in the form of clear black-and-white prints on glossy paper. Care should be taken to see that they cannot be bent or folded in handling *and paper clips should not be used.* All imperfections are reproduced.

Figures should each be numbered consecutively from I up for the entire manuscript. Use Roman numerals to number figures, and Arabic numerals to number tables. The legends for the illustrations should be typed upon a separate sheet placed at the end of the manuscript. Care should be taken to indicate plainly in the text the exact location of all illustrations and tables.

The Association will assume complete engraving expense.

Special Points of Style

USE OF NUMBERS

Use Arabic figures for all definite weights, measurements, percentages, and degrees of temperature (for example: 2 kgm., 1 inch, 20.5 cc., 300° C.). Spell out all indefinite and approximate periods of time (for example: over one hundred years ago, about two-and-one-half hours). For numerals used in a general sense, spell out numbers through ten and use Arabic figures for 11 and over (seven times, five years old, 11 students).

ABBREVIATIONS AND SYMBOLS

Standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kg., 6.25 cc., etc. The forms to be used (for both singular and plural) are: ft., ft.-lb., ft/sec, in., yd., min., hr., sq. ft., sq. in., rpm. *Gram* should be spelled out in all cases to avoid possible confusion with *grain;* also spell out *mile.* All obscure and ambiguous abbreviations should be avoided. Symbols used should follow the notation listed in *Research Methods* (AAHPER), pp. 518-20 and 522-25. Most common are:

M = mean	r = Pearson correlation
Mdn = median	r_{bis} = biserial correlation
N = number of individuals	r_{11} = reliability coefficient
n = number of measurements	χ^2 = chi square
σ = standard deviation	F = variance ratio
σ_M = standard error of mean	t = Student (Fisher) t ratio

Per cent should be two words. Use per cent sign (%) in tables or when it appears in parentheses in text.

Proofreading

The author will receive his original manuscript and any engraver's proofs with the galley proofs of his article for correction. A reprint order blank will be enclosed for the author's convenience.

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